UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
REGION 8
Albuquerque, New Mexico

Hugh G. Calkins, Regional Conservator

FOREST SURVEY PROCEDURE

AND TECHNIQUES

Regional Bulletin No. 70
Forestry Series No. 11
September 9, 1940

#1841

FOREST SURVEY PROCEDURE

AND TECHNIQUE

PREPARED BY

MEMBERS OF FORESTRY DIVISION

Issued at Albuquerque, New Mexico, for
use of Forestry Technicians of Soil
Conservation Service

FOREST SURVEY PROCEDURE AND TECHNIQUES

Basic Considerations

Forest surveys are a fact finding phase of land-use programs. The facts gathered on forest surveys are used, after analysis, in preparing a timber management plan and as this plan constitutes a prescription for systematic handling of a woods, aimed toward the silvicultural development of the stand to its highest productiveness, it is important to get a true picture and analysis, as a basis for this prescription. In the conduct of a forest enterprise, it is necessary to know not only growth rate and stand condition, but also general market conditions as a basis for knowing which species to favor and the size and quality of product desired.

While it is essential that some factual material as to physical conditions be obtained for planning purposes, it is also recognized that this information need not be of the same intensity for all forest areas representing varying types and conditions. Data for planning will pertain not only to management of the timber resource itself but to management of the land area from the standpoint of watershed protection. Minimum needs for erosion control will be determined on all areas. The diagnosis for management may require merely a walk through the woods or it may require a 100% cruise, depending upon markets, species, stand conditions and the desire and capabilities of the owner. Before initiating a forest survey, therefore, it becomes necessary to determine the intensity necessary and justified for each individual case. The determination of this intensity is of major importance as the costs involved should be justified by the usefulness of the data developed by the survey. A determination of the intensity required involves the application of certain recognized criteria, but in large part must be based upon the judgment of the individual forester as conditions, both economic and physical, vary with every area.

The material presented here is for use as a guide in determining where surveys are needed, the intensity required or justified, and the procedure and methods likely to give the best results. These will vary, of course, with timber type, market and other conditions. It is realized that some of the material presented is sketchy. The present purpose is to make available what has now been developed and considered useful, with the expectation of adding from time to time to that here presented.

Intensity and Type of Survey

As a basis for determining intensity for any given survey, it is recognized that some preliminary investigation, which might also be termed a survey, is necessary to secure some idea of the conditions involved. In most cases it is believed that Area personnel have a general knowledge of forest conditions found on their Areas and that they have a fair idea of where further surveys might be needed.

The first step in determining the required intensity of survey for a given unit would be to make a low intensity survey of timber areas and a utilization survey to determine present use and possible outlets that could be developed for forest products. This might be called a preliminary study of economic and physical factors and would be obtained by a field study if analyzing facts already accumulated by Area technicians will not furnish reliable data. A preliminary reconnaissance would furnish data on the amount of forest area by major types, the present and potential condition of the stand, whether enough volume of merchantable timber is available for personal use, sale, or both, with notes as to management including cutting, grazing, protection and planting. Provided the preliminary reconnaissance of timber stands indicates sufficient merchantable volume for use, a utilization survey is made. This utilization survey constituting a detailed study of existing and possible markets would show the use that could be made to supply personal needs and the possibilities for sales of wood products for which a demand exists or for which markets could be developed.

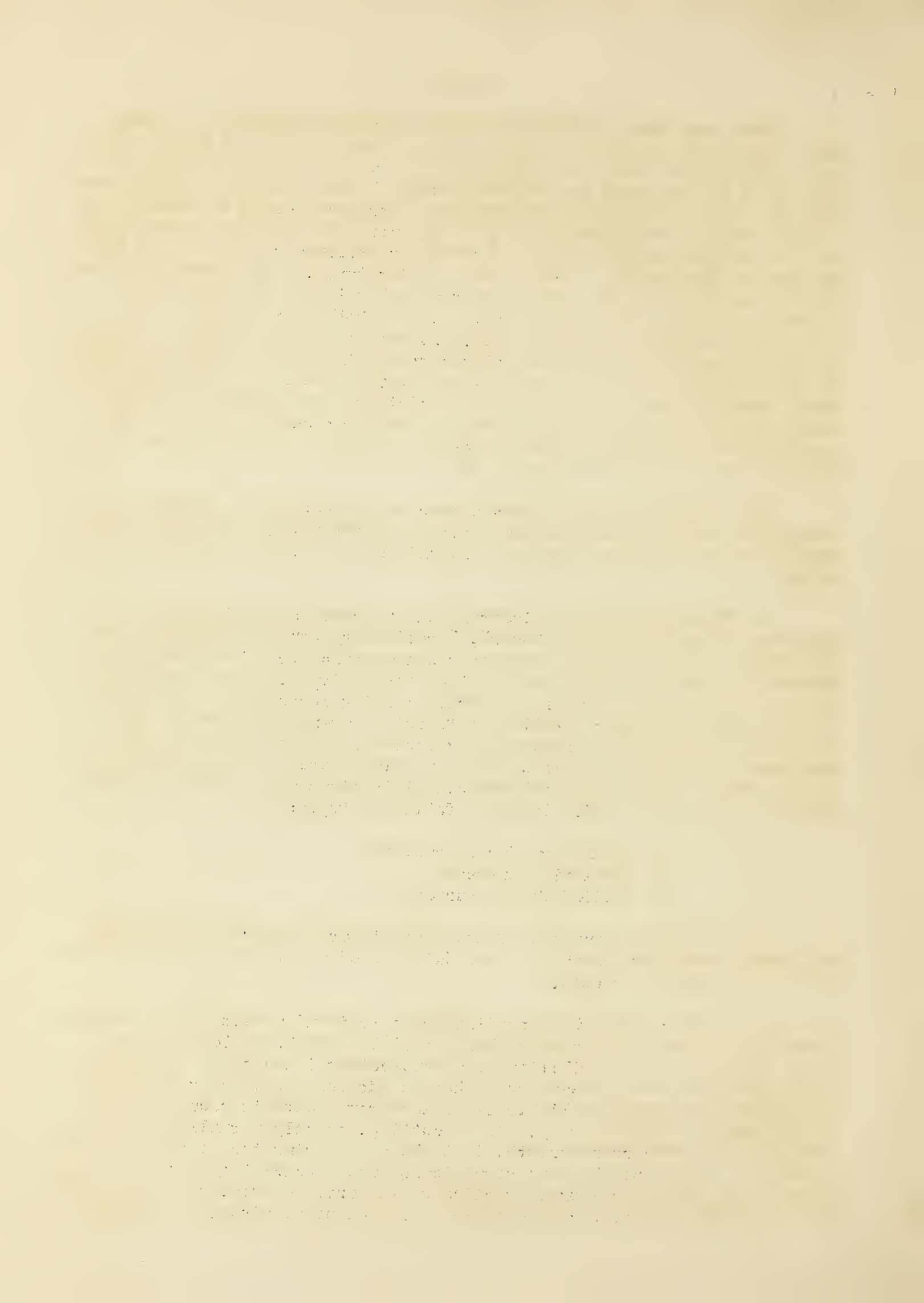
An analysis of these summary data covering both the physical and utilization surveys will furnish a basis for determining the type and intensity of more detailed surveys of the unit as a whole or for any of its parts.

In "Instructions for Engineering and Operations and Schedule for Reporting Accomplishments and Costs", "Preliminary Forest Surveys" are classified as "any over-all survey or reconnaissance for the purpose of securing general information on extent of forest types, stand conditions and related factors. Useful for general planning purposes, but not detailed enough to allow preparation of forest management plans." "Detailed Forest Survey" is defined as any forest survey of an intensity sufficient to furnish reliable data for regulated use and management of wooded areas. Using these two broad classifications and adding the utilization survey as a third, gives the following types:

1. Preliminary forest survey
2. Utilization survey
3. Detailed forest survey

The intensity of any one of the above types may also vary within the class, depending upon the type of data needed and the reliability required for planning purposes.

For timber stands where preliminary forest and utilization surveys indicate the presence of merchantable material that should be cut and where there is also a possibility of an overcut as indicated by probable sale within the next few years or by home needs for woodland products, a regulatory plan based on reliable stand and growth data is required and necessitates a detailed survey. If no cutting, or only a small amount of cutting well below current growth, is to be made during the next 10 years, regulation of cut would have no significance and a general type of plan prescribing good silvicultural practice would serve management needs. Detailed surveys for this second example would not be required. However,



sufficient information should be secured to prevent any possible over-cutting.

It would be advantageous, however, to secure growth and stand data for representative holdings even where no cutting or only a silvicultural cutting will be done within the next 10 to 20 years. These data would provide information convertible to economic values which would be useful in developing woods appreciation on the part of landowners whose holdings fall within this class.

On areas where economic and physical conditions, as shown by the preliminary analysis, indicate that intensive management will be feasible, planning needs call for a survey which will furnish inventory data of a high degree of reliability. The type of data required and the reliability requirement of these data will depend upon the intensity of management possible. Sound judgment is needed in a determination of intensity of survey required. The percent cruise on a physical survey does not indicate the intensity of a given survey in relation to the relative reliability of the data collected. As Mr. Preston stated in 1934, "We are beginning to learn the futility of adhering to a five or ten percent cruise or some fixed, preconceived standard of area to be covered by the cruise. The moderan idea is to recognize and map the timber types and then take enough samples in each type to satisfy the purposes of the cruise." The number of samples necessary for a given degree of reliability varies considerably in accordance with stand and type uniformity and size of area, indicating a much greater intensity on very small farm woodlands than on extensive forests under one ownership.

Regardless of the expected intensity of the first survey made, it is well to develop the survey pattern in such a manner that all the original survey data can be utilized in connection with a more intensive survey of the same area at a later date. The degree of accuracy justified at the present time might be less than will be required at some future date due to a change in economic conditions. The line-sample-plot system of survey lends itself most readily to increase of intensity by using data already collected and adding such plots as are required to secure the desired accuracy. Survey records must be so kept that the location of plot lines run can be readily determined as their location is important with reference to location of additional plots for increasing the reliability of survey data.

Methods for testing the adequacy of sampling will be found in Supplement No. 1 to this Bulletin. The error calculated in a test of adequacy gives measure of the probable error of sampling.

Inaccuracies in the volume and growth data secured on a given cruise may result from errors in sample plot dimensions, tree diameters and heights, volume tables, type area, etc. and can only be ascertained by field tests and check cruises.

Utilization Survey

As stated previously under "Intensity and Type of Survey", one of

the first steps in determining survey intensity for any given unit would be an over-all utilization survey. A study would be made of use of wood products by consumption areas, including larger cities, to determine the amount and kind of forest products being used in the various communities. Information as to salable products and prices on this general study will be useful in planning the individual land units.

In planning for the individual farm, one needs to determine the amount and kind of material needed for home use. Management of any woodland where all growth is not needed for home consumption, requires a knowledge of markets for wood products including minimum dimensions and specifications of quality. This is a prerequisite to determining desirable species for which to manage and the rotation required to furnish the products in demand. Sample schedules for securing utilization data are included in the Appendix.

Detailed Forest Survey

Planning the Detailed Forest Survey:

Whether a survey is to be made by one man or an organized crew, the success of the job as to costs and adequacy of results is largely dependent upon the plans made for its conduct. If a work plan is made covering the data to be collected and the manner in which it is to be obtained and worked up, the liability of neglecting to secure some necessary data is reduced to a minimum. For this reason, the plan should cover the survey processes in detail. The individual work plan will apply to the specific areas to be surveyed and to the manner in which the work will be carried out and should be based on a preliminary examination of the area. A survey work plan should be submitted to the Regional Forestry Division office for any survey of areas in excess of 2000 acres on one person's holdings or Land Utilization areas. Work plans for smaller units may be referred to the Regional Forestry office for checking if desired. A list of things to consider in the work plan follows:

Purpose of the survey
General description of conditions of timber
Area to be covered
Previous forest survey data available
Available base maps
Use to be made of aerial pictures
Data to be collected - volume, growth, stand condition, mapping system

Methods of field work including:

1. Crew organization
2. Training of personnel
3. Mapping
4. Typing
5. Estimating (diameter, heights, tree classification)
   (Estimates by 40's, sections, drainages, etc.)

6. Growth and yield data
7. Volume tables
8. Forms to be used
9. Inspection and field checks
10. Marking of control lines, plot lines
11. Records

Cost estimates
(Sample outline in Appendix)

Use of Aerial Photographs:

Aerial photographs where available should be used in connection with surveys to make any possible saving in time and to check against field results as to location, type area, etc.

By the use of photographs of the proper scale, which have been taken in accordance with timber survey needs, it is possible to make reliable volumetric estimates from measurements of tree images. Tree heights and tree crown diameters are readily measurable from the pictures. Considerable work along such lines has been done in Europe and in Canada. While the scale of our air photographs is much too small for such refinement, it is possible to distinguish between broad types and density classes and to obtain a good knowledge of topographic features. The pictures can therefore be used to advantage in a preliminary study of the area and if a survey is decided upon, they will be of considerable help in deciding on intensity of cruise needed from the standpoint of uniformity of density and area of types. On small percent surveys aerial pictures are of material aid in choosing location of plot lines to bisect representative types in order to secure samples of these types with the least effort.

On extensive surveys field data may be shown directly on blue line ozalid prints, made from the photographs, if desired, or on overlay sheets using the same scale.

Mapping:

Maps serve not only in giving a graphic presentation of topography, but also as a record of area and location of timber types and age classes and other features of importance in management of the area.

Before field work starts, the best available map of the area should be obtained, or, when they can be prepared, planimetric maps from aerial photographs will be used. If planimetric maps cannot be obtained and the area has been surveyed by the General Land office, a base map may be prepared from G.L.O. plats and intersections of topographic features with section lines will be shown. If such a survey has not been made but the area has been mapped by the U. S. Geological Survey, the base map may be prepared from U.S.G.S. maps and the control lines will be tied to permanent bench marks or triangulation points. Usually base maps will be required by other divisions of the Service and will be supplied by the Cartographic Division.

Control lines should start from known corners and tie in at frequent intervals to established corners. The control lines will traverse the area in such a manner as to permit the cruise lines to run at right angles to the prevailing topography. The control lines, when run with compass and chain, should have an error of closure not exceeding 25 links per mile. Transit line errors should be correspondingly smaller. Accurate notes of the control line as well as a sketch map will be kept for future reference.

On unsurveyed areas the control lines will tie into known points, these to be present upon the base map or easily recognized on the aerial photographs so that they may be readily and accurately placed on the base map. All stations which are to be of a semi-permanent or permanent nature should be of capped 1½" galvanized iron pipe with the station number plainly marked on the cap. These stations will each be witnessed where practicable by definite nearby landmarks and where none exist by two trees blazed with the following notations scribed on the wood $\frac{(T.S.C.)}{(Sta.\ 4)}$, meaning timber survey control line, Station No. 4. These primary control lines should be accurately shown on field maps and estimate sheets but will only be established for large areas of land not covered by G.L.O. surveys in instances where plane table mapping is desirable and no base line occurs within reasonable distance of the area to be mapped.

For field mapping a scale of 4 inches per mile or larger is preferable. On low intensity surveys a smaller scale not less than 2" per mile may be used if such maps are available and larger scale maps are not readily obtainable.

Maps will show age classes and types and such other data as is decided upon and covered in the work plan for the individual survey. Care should be taken to make clear, accurate maps in the field. Camp maps should be kept up to date at all times. Each field map should show clearly the points of the control system to which the map is tied and G.L.O. or traverse corners from which the work starts and where it stops as well as established corners used as checks.

Plot Survey Lines:

The line-sample-plot method is considered as preferable for surveys of all classes except those of high intensity such as might be employed on small farm woodlots. Circular plots of 1/5, 1/4 or 1/2 acre are usually used. The 1/5 acre plot is favored in very dense stands while plots of 1/2 acre or sometimes 1 acre are used in open stands. The plot system can be used by a one or two man crew and the data taken lend themselves to statistical analysis and to use of plots already taken when a more intensive coverage is found desirable. In order to secure additional plots to increase the reliability of data for the entire area or for some individual compartment, it is essential that plot survey lines be located on the map and that they be marked on the control lines. This is necessary so that location of additional plots can be selected to give a more representative sampling. A list of advantages of the line-plot method and a table of Plot Radii are given in the Appendix.

Estimating:

There is considerable possibility of error in estimating resulting primarily from errors in estimating sample-plot dimensions, tree diameters and heights (merchantable or total), cull, etc. All these errors can be largely eliminated by careful training, careful estimating and the application of frequent check measurements. Crew members should measure all trees the first three or four days. This should be done by guessing the measurements being taken (diameter, heights, plot radius) before taking the measurements. This training period will differ for individuals and one can judge its length by the correctness of his estimating. The estimator should never depend on his eye alone, but should always measure from 20 to 25 percent of the trees of merchantable size, preferably the larger trees. It is especially important to make checks when starting work in the morning, immediately after lunch, and in the afternoon when one is apt to become tired mentally. The merchantable length of a tree appears differently to the estimator depending on whether he is going up or down hill. Heights can be taken with an Abney level. If a sufficient number of windfalls are available close to the cruise line, they afford a good check on merchantable heights.

To prevent large volume errors, care should be taken to obtain volume tables which have been constructed for the forest being surveyed or for the general region in which the work is being done. In the latter case the table should be checked against the timber to be estimated. This may be done by measuring windfalls or by cutting sufficient trees to obtain a representative sample to be used in establishing a correction factor for the volume table. Juniper tables can be checked by measuring the standing trees without cutting.

To assure getting all trees on the plot and only those on the plot, the estimator must pace out to the edge of his plot frequently to keep his eye adjusted to the proper distance. A small but consistent error in plot size will make a large error in the estimate for the area. To be sure his paced distances are correct, he should also test pacing against measured distances at frequent intervals.

Every timber cruiser should become familiar with the volume of individual trees of different sizes and species and should learn how to estimate the volume of individual trees and to judge the stand per acre. In order to develop this judgment it should be common practice to figure the volumes on at least 10 percent of the plots while the estimator is on the plot. Details of estimating pertaining to individual types will be further discussed under methods pertaining to those types.

Checking and Inspection:

Every cruiser in a survey crew should be checked by the chief of party (usually the Senior Forestry Technician) sufficiently often to make sure that his work is up to standard. Under the line-sample-plot method, where the line intersection with the control line is marked and the plots are marked by center stakes, sufficient plots should be taken to determine whether the work is satisfactory. In such cases the difference in

gross volume should not be more than 6 percent. The work should be checked regularly at least every ten days and preferably more often. The object of checking is training with the idea of obtaining consistent and accurate results. Errors are of two kinds:

1. Those resulting from faulty or inaccurate work such as poor estimating, faulty use of instruments, faulty pacing and careless recording.

2. Inadequacy of sampling resulting in too great a standard error in view of the use to be made of the data. As the allowable error of sampling is to be set before the cruise is started, it is necessary to measure the variation factor and determine whether or not sufficient plots are being taken to furnish data of the required reliability. The exact intensity of sampling required to insure a certain degree of accuracy cannot be calculated until it is definitely determined how variations in forest conditions existing on the area affect the average volume per acre. An experienced cruiser can estimate closely, on the basis of a preliminary investigation of a tract, approximately what intensity of sampling will be required for a reliable estimate of the volume. Through daily analysis of plots, adjustments can be made on individual units. Methods for making a determination of the required intensity will be found in Supplement No. 1 to this Bulletin.

Standard Types and Legends:

In the interest of uniformity and interpretation of survey data, standard types descriptions and legends have been prepared for regional use. These will be found in the Appendix. The standard types shown, except for the non-use type, are based entirely upon vegetative species present. The non-use type is set up for types for which, because of their condition, non-use of forest products is recommended. This non-use type is primarily for showing areas of use and non-use for administrative control of cutting. Where it is used the vegetative type will be shown by the vegetative type symbols. Areas which will not be used due to inaccessibility should be typed according to vegetative type. Their inaccessibility may be shown by symbols if desired and covered in the narrative description. Where it is desirable to indicate forest conditions, present or proposed use (other than non-use), other symbols can be used illustrating these conditions. The data to be shown for each survey and the manner in which it will be shown will be covered in the survey work plan.

Reports:

Report preparation is one of the most important phases of any survey. The report should, in a fairly brief presentation, give all the pertinent facts necessary to an interpretation of volume, growth and other data required for the preparation of management plans. These facts should be reported clearly and while interpretation and opinions may be given, the field data must be so recorded and filed that they can be analyzed at any

time either to check against recommendations and conclusions covered in the report or to determine the reliability of the data with reference to the whole area or to a small compartment or separate subwatershed. The material covering the work plan, and the final survey report will be kept in one file appropriately marked. The field data sheets and maps may be stored in a transfer case if too voluminous to keep with the report, but a reference sheet should be kept with the plan and report, giving the location of this supporting data. All material should be plainly marked so that it can be readily identified.

The coverage and length of a survey report will depend upon the purpose of the survey and the use to be made of the information gathered. A report outline should be made prior to the survey.

As a minimum, the report, even on a small woodlot, should include:

1. Legal description and ownership
2. Dates of cruise
3. Area cruised
4. Itemized statement of net volume by species
5. Plat of area
6. Statement of sampling percentage and method
7. Log or volume tables used
8. Brief description of size and quality of timber

Sample report outlines will be found in the Appendix.

Methods of Inventory According to Timber Types and Intensity of Survey Required:

In the discussion of individual species and types which follow, it is assumed that preliminary forest surveys and utilization surveys show the need for more detailed surveys.

Ponderosa Pine; Douglas Fir; Engelmann Spruce:

The type of survey to be made will depend upon the type of stand under consideration. For stands where regulation of cut would have no significance or use during the next 10 years, it is usually not advisable to incur the expense necessary to secure complete stand and growth data. An exception to this would be representative stands in each community on which data on volume and growth would be worked up in order to illustrate future values and the need for proper protection and care by the land owner. These data would be used in developing woods appreciation and the number of examples required would largely depend upon the diversity of conditions found in each community.

Except for these representative sample stands, a plan prescribing good silvicultural practice should provide for present needs. Examples of stands where this type of plan is required are given below:

1. A stand consisting almost entirely of young reproduction having no old trees or only a few old trees not in excess of seed tree needs.

A reconnaissance type of examination or a walk through the stand should furnish the information required in preparation of a plan covering protection, general management, and silvicultural policies applicable to the particular woodland.

2. A stand consisting mostly of young growth which will not be merchantable for 25 years or more with an overstory of scattered even-aged, over-mature trees.

A plan covering protection needs and providing for good silvicultural practice such as leaving some of the better old trees for reserve seed trees would satisfy present management needs. In a stand of this type the mature trees are in need of cutting and a period of considerable length is necessary to bring the young trees to harvest size. As the over-mature trees will lose volume through insects and decay and as there is not sufficient volume in any case to supply the general market, the only cutting restrictions needed would be to regulate the harvest to meet farm or ranch needs or to aid in securing reproduction.

3. A stand of poles which will reach prop size in from 12 to 15 years.

Only a general plan is required covering protection and general silvicultural requirements as to thinnings, if any are possible, to furnish products for home use. In addition to the above general recommendations, it would be well to indicate probable annual yield at the beginning of the period when cutting will be possible. This information can be based on a low percent cruise and may or may not be necessary, depending upon the attitude of the landowner.

On stands where, in addition to general silvicultural practices needed to develop a desirable woodland stand, more intensive management and regulation is possible, it is necessary to determine volume, growth and stand condition. These data, together with a knowledge of market conditions, would form a basis for determining the annual or periodic cut as to amount of material and the species and age groups from which this cut should come.

In any stand where regulation is possible, it is desirable the annual or periodic cuts not exceed the amount of growth during a similar period. This may not always be possible since changes in market conditions may necessitate the establishment of shorter rotations to supply products of smaller size as ties and props. It is desirable to determine the rate of growth of the stand. Where stands are more or less homogeneous, it is possible to determine reliable average growth rates for broad types over relatively large areas as recommended by George F. Rupp in "A Simple Method of Securing the Technical Data Necessary in Preparation of Woodland Management Plans." Except for a few of the more extensive pine areas in the region, this method of securing growth data will have little application because of the patchy and diversified condition of timber types and variation in site conditions. The alternative method of making growth studies by securing increment borings on each individual woodland can be applied on each pine survey. Under the Rupp

system 60 or more growth measurements in each type are considered necessary for a reliable sample. As this number applies to small farm woodlands, additional samples will be necessary for larger areas. The sample trees may be selected mechanically during the cruising operation by taking trees at definite intervals throughout the cruise such as the one, two or more trees nearest the center of the plot. On growth data trees the d.b.h. should be measured with a diameter tape and recorded to the nearest 1/10 inch. The width of the last ten annual rings should be measured and recorded to the nearest 1/20 inch.

The table of relative net growth percents prepared by the Forest Service listed as a reference in the Appendix, may be used for comparative purposes in connection with growth studies of local ponderosa pine stands.

While the system outlined for securing growth percent has general application, a more diversified application of techniques is advisable, according to stand and market conditions, for securing data required on volume and stand condition.

On timber areas where annual or frequent periodic cuts are possible such as might be the case where conditions are favorable to management for production of ties and props, the basal area system given by Rupp should be most satisfactory. For details of that system and forms for collection and presentation of data, you are referred to his write-up.

On timber areas of fairly large size where cuts are likely to be based on cutting cycles in excess of 10 years, it is possible to work out regulated cuts for the forest as a whole on a fairly extensive cruise by the line-sample-plot system and to secure the data in such a manner that its reliability can be determined. On this type of stand, it is recommended that trees on the plots be recorded either by d.b.h. and number of 16-foot logs to a 8" top or d.b.h. and total height and recorded under cut and leave classifications. For ponderosa pine stands, Keen's Age and Vigor Classification as modified by the Forest Service (see Appendix) should be used as a guide for the determination of cut and leave. In recording merchantable heights, a suitable merchantable height volume table should be secured and checked prior to the survey.

The percent of coverage or intensity of sampling needed will, as stated previously, be dependent upon the stumpage values involved, size and uniformity of timber areas and other factors. For any survey where volume and growth data are to be used as a basis of regulating cut or for making sales, a cruise that will check out within 10 percent is considered necessary. On timber of high value or where especially accurate results are required such as cruises made for the purpose of appraisal for purchase, the cruise should be of sufficient intensity to check within 5 percent. On small farm woodlands of less than 100 acres, it would probably be necessary to cruise from 25 to 100 percent of the area to attain the necessary reliability. On larger holdings the percent cruise will decrease quite rapidly to as low as $2\frac{1}{2}$ percent on a 20,000 acre forest area.

Type mapping will also vary. On the larger holdings no type smaller than 10 acres would be mapped, while on small holdings, one would need to consider areas as small as one acre.

Normally the map prepared of the forest area will show cover types and age classes. Where desirable, additional information pertaining to condition and recommended use or protection may be indicated by appropriate symbols.

Age Classes for trees below 12" in diameter will be as follows:

1. Trees less than 4½ feet high--reproduction.
2. Trees from 0 to 4 inches d.b.h. and 4½ feet or over in height--saplings.
3. Trees from 4 to 12 inches d.b.h.--poles

Clumps of seedlings will be treated as follows:

Clumps of 1 mil-acre (6.6 ft. x 6.6 ft.) will be recorded as one seedling.
Each additional mil-acre as one seedling.

In presenting the survey data in the form of a report, it is necessary to show summary results for cooperators in simple understandable terms. Copies of the work plan, all field sheets and maps, compilation sheets, etc. will be filed in the area file. If all such data are plainly labeled, they can be referred to in connection with any check survey or cruise of greater intensity at a later date.

Other Saw Timber Types:

In making surveys of douglas fir and other saw timber types, the general procedures used in the ponderosa pine type apply, with a few exceptions.

The tree classification system used on ponderosa pine is, of course, not applicable to other species. As a similar system has not been worked out, cut and leave trees may be tallied. The estimator, in such cases, will determine as the trees are recorded whether they would be cut or left under marking rules applicable to the type being surveyed.

Pinon-Juniper:

Pinon-juniper areas are used primarily for fuel and fence post production. In special instances other products may be important, such as props, and pinon is of importance for pinon nut production.

Several species of juniper are found in these stands and for some of them information concerning silvicultural requirements, volume, growth and yield is very limited. The stands vary considerably as to use and condition. Many stands will show over-use of fuel and post material, and over-use of post material will probably be the general, rather than the exceptional, condition. The problem will be, using such data as have

been developed, to study the conditions of each case and to determine survey intensity needs required to control the use of an important resource but in so doing to fit the management intensity to the requirements of a slow growing forest type having a low commerical value.

Because of the high use value of this species, a utilization survey to determine home-use needs for post and fuel will usually be required. With this information at hand, production above these needs could be made available for sale or use on other areas.

In most cases a reconnaissance is advisable to indicate the use being made of the area which will indicate the type and intensity of further surveys required as a basis for proper control of use.

If the indications are that some units are over-cut but that the area as a whole is not, and increased use is not probable, a low intensity survey giving sufficient coverage to locate areas where controlled cutting of posts or fuel is possible and areas which should be closed to cutting would cover existing management needs. A survey of this type would be applicable to fairly large areas used as community woodland such as some of the LU and Grant areas. In such cases, condition and use maps can be applied as a basis for control of cutting by using symbols to indicate non-use and use areas. These use types will be based upon age, density and condition of the timber and also upon a consideration of erosion conditions and need for protection. Cutting will be based upon silvicultural requirements of the stand. Consequently no volume and growth data will be procured.

Where woodland areas are being over cut or where indications are that the drain of products is approaching or exceeding growth, a need for regulation of cut is indicated and a survey of sufficient intensity to furnish volume and growth data in addition to stand condition is required. The intensity required will depend upon size of area and uniformity of types, but usually the requirements of the survey can be satisfied by a lower degree of accuracy than is required for timber species representing higher values. A standard error of the mean of 15 percent should be satisfactory for the most intensive survey of pinon-juniper areas.

On any farm or ranch it is advisable to make enough of a survey to determine home needs and to determine whether these needs can be filled by home-grown woodland. If sales are probable or possible, the amount of posts, fuel, etc. which can be sold within the next 10-year period should be determined. For stands with a fair representation of size classes, studies made indicate an average growth rate of a little over 1 percent for pinon-juniper stands (pinus edulis and juniperus monosperma). An application of this growth rate can be used for similar stands. For stands composed largely of young or of old trees growth data are needed.

For a prediction of available posts and post production, stems having post length should be recorded according to diameter at 6½ feet above the stump, or top diameter of post, down to a 2" diameter or lower if found desirable. On the basis of data taken for volume table construction, diameter increase at stump height averages approximately 1/2"

in 10 years. In order to check the relationship in increase in diameter at 1 foot and at 7½ feet and to determine the rate of growth for given juniper stands, enough of a growth study will be required to establish usable data.

A sample post form which can be changed to meet local conditions will be found in the Appendix. By an actual count of post length material according to size classes, an estimate can be made as to the posts now available, and the posts that will be available during fairly definite periods in the future. Where necessary, these figures for posts available could be tallied according to cut and leave. Where a stem which is post size now happens to have one or more limbs slightly under post size, it would pay to leave it until the limbs will also be usable as otherwise the growth already put on over a considerable period of years will be wasted.

When tallying split posts make allowance in the number tallied for defect. It is best to do this while the survey is in progress.

In making growth studies of juniper, care should be exercised in counting, as false rings are quite common. A lens should be used for counting.

Survey Procedure

Pinon-juniper surveys will usually be made by the line plot method. Suggestions covering the preparation of estimate forms will be found in the Appendix. A separate sheet should be used for each plot, type or other survey unit.

Reference is made to Regional Bulletin No. 59 for volume tables for juniper species. Of the tables thus far developed, those based on the following measurements are considered the most reliable.

Juniperus monosperma- diameter at one foot and crown width- cu.vol.
(On clumps having several stems, use the diameter one foot above the ground of the tallest stem)
Juniperus scopulorum- Diameter at one foot and crown width- cu.vol.
Pinus edulis- D.B.H. and number of 4' pieces- cu.vol.

In using existing tables it will be necessary to secure data for local stands as a check against the volume table. This may be done by recording the middle diameter 2 inches and over of all 4' pieces on every 5th or 10th plot in juniper areas as it is possible to secure these data without cutting down the trees. By the use of Huber's formula for volume of cylinders, a comparative figure can be secured for correcting the volume table figures. This may be done by the procedure outlined on Page 34 of the Appendix.

On large areas, especially those subject to community use, non-use areas should as far as possible be delineated prior to cruising.

For securing post estimates, it will be necessary to tally the number of posts on the plot or area sample. Under-sized material may be tallied where future cut information is desired. Under-size material which has post length but dead tops should be thrown out as it will not produce post material.

Reproduction is that material 4½ feet or less in height.

The data should be shown, in the final report, in common units such as cords and number of posts. In some areas where only dead wood is to be cut, there may be a need for regulation of the cut to provide for local needs in a systematic manner.

Mesquite:

Mesquite is used primarily for fuel and posts. Where a preliminary study indicates cutting does not approach the growth, a silvicultural plan indicating proper cutting practices will provide for present needs. Information on proper handling to lessen powder post beetle damage should be supplied owners of mesquite woodland. This may include recommendations that peeled rather than unpeeled posts be used if evidence can be obtained to support such conclusions.

Where material being cut approaches the growth or where sales are contemplated, a survey to determine volume and growth is required. Because of the relatively low initial cost for wood or post cutting operations, a survey having a standard error of the mean of 10 percent is usually adequate. Where special values are involved, a more reliable estimate is needed.

In cruising mesquite to be harvested under conditions applying on Indian lands the volume table prepared for Southern Arizona should be checked and if found at variance with the stand to be cruised it should be corrected for local conditions. It is well to note that Olson disregarded large boles supporting smaller stems which might be harvested. This means that in his cruising he tallied all stems having a stump or basal diameter of 3" or greater by one inch diameter classes irrespective of whether these stems occurred as sprouts on large or small boles or stumps or on seedling stock. Thus his cruises were based upon methods of harvesting by Indians which may or may not apply on White owned lands and which accounts for his volume table extending only to 15 inches D.S.H. Further studies would be needed to determine volume where whole trees, many of large size, are to be cut. After the initial cut, however, Olson's data could after checking be used as a basis for determining volume and growth.

By Olson's method each 4 foot length in each stem with a middle diameter of 2 inches or greater outside bark was included to get the volume of each stem. The diameter measurement was made at one foot from the ground on seedling stems and at 4 inches from the point of origin on

sprouts originating on shoots. As a high degree of homogeneity was found between coppice and seedlings, one table was made for use on both types of stand. As basal diameter gave a very high correlation with cubic volume, the volume table is based on diameter alone. In using this table only the diameter to the nearest inch is recorded.

Where it is desirable to show volume by cords, a converting factor may be determined for the individual stand by measurement of stacked volume.

Where post estimates are desired, posts should be tallied on each plot by the estimator.

For more detailed information on mesquite surveys, refer to Regional Bulletin No. 59, Forestry Series No. 10, prepared by Mr. C. E. Olson and request from the Regional office the loan of one of the mesquite management plans prepared by Olson.

REFERENCES

1. Preston, John F. 1934. Better Cruising Methods. Jour. Forestry 32: 876-878

2. Girard, James W. and Govorkiantz, Suren R. 1939. Timber Cruising. Forest Service. (Multilithed)

3. Rupp, George F. 1938. A Simple Method of Securing the Technical Data Necessary for the Preparation of Woodland Management Plans. Soil Conservation Service (mimeographed)

4. Bruce, Donald and Schumacher, F. X. 1935. Forest Mensuration. McGraw-Hill Book Company

5. Kline, C. W. and Myer, W. H. 1934. Intensity of Timber Cruises and Its Relation to Accuracy. Jour. Forestry 32:352-353.

6. Forest Service, Region 4. 1937. Timber Survey Handbook (mimeographed)

7. Olson, C. E. 1940. Mesquite Woodlands on Southern Arizona Indian Reservations. Soil Conservation Service, Regional Bulletin No. 68, Forestry Series No. 10.

APPENDIX

Index

FOREWORD

In the appendix, we have attempted to include material that will be helpful in surveys. Obviously the color legend will be used where surveys are made on extensive areas as L.U. projects, large privately owned grants and other lands comprising one or more ownerships where timber stands cover a large acreage.

For small acreages of timber or woodland all that is needed is to indicate the type by symbols. Considering a drainage carrying 10 or more sections of timber involving several ownerships presenting conditions for satisfactory harvesting by but one operator, it would be well to have a map of the timber types in color for the entire unit so that the relation of timber ownership and timber volumes can be properly studied. When agreements are prepared for each of the individual ownerships the map accompanying each agreement would not need to show each timber type in color. However, the boundaries of each timber type should be shown and the type indicated by name or by symbol.

The timber survey forms are only suggestive. Those for tallying timber species have been tried out by the Forest Service for many years and have been found satisfactory. One other applying to post stands is as yet in the formative stage and can be improved upon or adapted to meet varying conditions.

#1323 WOOD UTILIZATION SURVEY Forestry Div., Reg. 8
January 1940

Cooperator _____ Agreement No. _____
State _____ Size of Farm _____ Acres
Area _____ Area in Woodland _____ Acres
Work Unit _____

I. Fence Posts

a. Miles (to nearest tenth) of fence to maintain _____ Miles
b. Average No. of posts per mile _____
c. Total posts in use (a x b) _____
d. Kind or species of trees used for posts (note if treated)

_____

_____

e. Length of life of posts (use averages) _____ Years
f. Average annual replacement (c ÷ e) _____
g. Cost of annual replacement (f x unit cost) $ _____

II. Fuel Wood

a. Cords (128 cu.ft.) of fuel wood used annually _____ Cords
1. Species used _____
2. Total annual value processed f.o.b. farmstead $ _____
b. Tons of coal used annually _____
1. Total annual cost f.o.b. farmstead $ _____

III. Lumber

a. Amount of rough lumber used annually (barn boards, planking, etc.) _____ Bd. Ft.
1. Value f.o.b. local mill $ _____
b. Amount of quality lumber used annually (finishing, etc.) _____ Bd. Ft.
1. Value f.o.b. retail yard $ _____

IV. Other Wood Products (Poles, Timbers, Etc.)

a. Annual amount (in cords, bd. ft., lineal ft., etc.)

_____

_____

1. Value $ _____

V. Summarization

Class of Wood Products	Annual Needs	Quantity Available from Nat. Forests or Grazing Service Lands	Balance
a. Fence Posts			
b. Fuel Wood			
c. Lumber			
d. Other Wood Products			

EXPLANATION AND USE OF FORM

Utility values to be expected from present or proposed forest areas are important to show land owners one form of use that may logically apply to their lands. Often the owner wants to know what he can expect from existing forest stands or from plantings.

The purpose of this form is to provide information to arouse interest in the development, maintenance and protection of farm woodlands.

With the exception of Item (I-d), all of the information under I can be obtained in the office. The length of fence can be scaled from the map in the cooperative agreement, remembering that as a rule a farmer maintains but half of his boundary fences. The mileage of fence on irrigated and on dry farm and range lands should at first be considered separately since length of life of posts is affected by differences in soil and moisture conditions. Number of posts per mile is a rather constant figure for any given locality. Length of life of various species of posts can be determined from the table accompanying this form with such adjustments as you deem satisfactory. Where steel posts are used, the range of life may vary from 7 to 30 years, depending upon the kind of post and where it is used.

Items under (II) can be obtained by questioning the cooperator. Notice that it is necessary to show stovewood in terms of standard cords.

The landowner will usually be unable to answer the question of how much lumber he uses annually. However, the technician can direct the landowner's thinking to furnish reasonably accurate answers, i.e. when was the last lumber purchased or sawed? How long before that did he buy or cut building material? Are new buildings contemplated? How much lumber was or is going to be used in specific buildings? Distinguish lumber that may be grown or manufactured locally and specialized material, as flooring, siding and other planing mill products of species not available in the immediate locality.

Item (IV) includes such products as poles, vigas, rough hewn timbers, etc.

Item (V) presents among other items the proportion of annual needs that can be continuously supplied from nearby National Forest or Grazing Service lands. Depending upon the opportunity afforded, products formerly obtained from these sources may in the future, in whole or in part, be provided from cooperator's lands.

This survey includes only material used on the farm or ranch; do not consider amounts cut for sale or use on other holdings.

This form should be filled out for each cooperator.

FENCE POST TABLE

Species	Average Years of Service [1]	
	Untreated	Treated[2]
Ash	6	25
Aspen	4	28
Black locust	30	37
Catalpa	20	-
Cottonwood	4	27
Desert willow	20	-
Douglas fir	7	-
Honey locust	12	27
Junipers[3] (various native species)	30	37
Lodgepole pine	4	30
Mulberry	20	-
Mesquite	20	-
Osage orange	30	-
Ponderosa pine	5	30
Rocky Mt. white oak[4]	15	-
Willow	3	27

1 Based on the best data available for average sized posts 7' long, top diameter 3-4 inches
2 Treated with creosote - hot and cold tank method
3 Figuring 4-5 inches of heartwood at the ground line
4 Set green with the bark on

It is difficult to prepare a table showing the average length of life of fence post woods. So many factors affecting durability are locally important.

Obviously, adjustments in "years of service" must be made for varying conditions of soil, climate, post size and condition, etc. in different localities. Wise use of the data in this table making such corrections for application as you feel you can substantiate should give information of reasonable reliability.

Please send to the Forestry Division, Regional Office, any data you can obtain on these or additional species as white mulberry, russian olive, or others which may locally be important.

Species and Type Symbols

Symbol	Common Name	Scientific Name
PP	Ponderosa Pine	Pinus ponderosa
LP	Lodgepole Pine	Pinus contorta
LbP	Limber Pine	Pinus flexilis
P	Pinon Pine	Pinus edulis & monophylla
DF	Douglas Fir	Pseudotsuga taxifolia
ESp	Engelmann Spruce	Picea engelmannii
BSp	Blue spruce	Picea pungens
WF	White Fir	Abies concolor
AF	Alpine Fir	Abies lasiocarpa
JS	Rocky Mountain Red Cedar	Juniperus scopulorum
JM	One-seed Juniper	Juniperus monosperma
JU	Utah Juniper	Juniperus utahensis
JP	Alligator Juniper	Juniperus pachyphloea
P-J	Pinon-Juniper	(mixed stand)
OE	Evergreen Oak	Quercus spp.
OD	Deciduous Oak	" "
A	Aspen	Populus tremuloides
M	Mesquite	Prosopis spp.
H	Misc. Hardwoods	
B	Barren	Note: Rather than use
Gr.	Grass	symbols on the map the
Clt.	Cultivated	cooperator receives.
Sgb.	Sagebrush	Write out the common
Br.	Brush	name of the species within the type.

DESCRIPTION OF TYPES*

Barren (B)

An area too rocky, too exposed, too arid, or at too high an elevation to support trees or grass or more than a very scattering growth of herbs and shrubs, or an area so repeatedly burned that it contains neither reproduction, grass, nor brush in appreciable quantities.

Burns (Bn)

This is applied to those areas which have suffered recent burns and have not had sufficient time for regeneration or do not have appreciable quantities of green, living material left standing. Where reproduction or other living material is of predominant importance the area should be classed as to the corresponding age class of the proper type together with the symbol for burn, the burned area to be distinctively typed on the cover type map.

Grass (Gr)

An area, such as a park, mountain meadow or treeless ridge, whose principal vegetation is grass and other herbs.

Cultivated (Clt)

An area now under cultivation or lying fallow.

Sagebrush (Sgb)

An area whose principal vegetation is sagebrush.

Brush (Br)

All other areas, the present cover of which is a stand of shrubs or stunted trees, not covered in types given below.

Pinon-Juniper (P-J)

A stand composed of approximately 60% or more of the various species of the pinons and junipers. The mixture is composed of nearly equal proportions of pinon and juniper. It is composed of single-leaf pinon (Pinus monophylla); pinon (Pinus edulis); Mexican pinon (Pinus cembroides); Rocky Mountain red cedar (Juniperus scopulorum); one-seed juniper (Juniperus monosperma); Utah juniper (Juniperus utahensis); big-berried juniper (Juniperus megalocarpa); Alligator juniper (Juniperus pachyphloea).

* For timber species apply percentages indicated in terms of the number of merchantable trees of various species obtained from the cruise. For woodland species estimate in terms of basal area of merchantable material.

Juniper (J)

A stand composed of approximately 60% or more of any species of juniper with very little or no pinon. The species found in this region are Rocky Mountain red cedar (Juniperus scopulorum); one-seed juniper (Juniperus monosperma); Utah juniper (Juniperus utahensis); big-berried juniper (Juniperus megalocarpa); and Alligator juniper (Juniperus pachyphloea).

Pinon (P)

A stand composed of approximately 60% or more of any species of pinon with very little or no juniper, but possibly some ponderosa pine. The species found in this region are single-leaf pinon (Pinus monophylla); pinon (Pinus edulis); and Mexican pinon (Pinus cembroides).

Oak (O)

A stand composed of approximately 60% or more of any species of oak with some or no juniper, pinon or other species. The following species may form types in this region: white-leaf oak (Quercus hypoleuca); emory oak (Quercus emoryi); blue oak (Quercus oblongifolia); Arizona oak (Quercus arizonica); gambell oak or Utah oak (Quercus gambelli or Q. utahensis), or the evergreen oaks in mixture, or mixed oaks of major or minor importance.

Mesquite (M)

A stand composed of 60% or more of the various species of mesquite; Prosopis juliflora, P. julifora glandulosa, P. juliflora velutina and P. pubescens.

Ponderosa Pine (PP)

A stand composed of 50% or more of ponderosa pine. Usually on dry, well drained sites at the lower altitudinal limit of timberland or on exposed south and southwest slopes at the higher elevations.

In Colorado it will be found in mixture with douglas fir, white fir, blue spruce, and lodgepole pine. In Utah it will be found in mixture with douglas fir, white fir and lodgepole pine. In New Mexico and Arizona it is found in mixture with white fir, douglas fir, and, rarely, with blue spruce.

Lodgepole Pine (LP)

A stand containing approximately 50% or more of lodgepole pine, usually nearly pure, but sometimes in mixture with other species. In Utah and Colorado it is found in mixture with douglas fir, engelmann spruce, alpine fir, blue spruce, bristlecone pine and limber pine.

Lodgepole Pine - Douglas Fir (LP-DF)

A stand containing at least 60% of these two species, but insufficient quantities of either one to make logical a more distinctive classification. Other species usually in the mixture are engelmann spruce and alpine fir.

Limber Pine (LbP)

A stand containing approximately 60% or more of limber pine, seldom pure, usually in mixture with lodgepole pine, douglas fir, engelmann spruce and alpine fir. At medium elevations, usually on poor sites and dry, warm exposures of limestone or sandstone.

Douglas Fir (DF)

A stand containing approximately 60% or more of douglas fir. The principal species in mixture are ponderosa pine, lodgepole pine, limber pine, white fir and blue spruce.

Douglas Fir - Spruce (DF-Sp)

A stand composed of approximately 60% or more of douglas fir and engelmann spruce in varying mixture. Other species in mixture are ponderosa pine and lodgepole pine.

Spruce (Sp)

A stand composed chiefly of one of the species used economically and containing 50% or more of the species, sometimes in mixtures.

In the Rocky Mountains engelmann spruce sometimes with blue spruce on moist sites or at high elevations, may be pure, but is more often in mixture with alpine fir, lodgepole pine, limber pine, douglas fir and, occasionally, with bristlecone pine. In Arizona and New Mexico engelmann spruce, sometimes blue spruce, is usually mixed with alpine fir, corkbark fir, douglas fir or bristlecone pine. The type occurs only at the higher elevations, usually near the upper limit of timberline.

Fir (F)

A stand containing approximately 50% or more of one or more species of true firs. Either in combination or singly, usually predominate. The species found within the region are cork-bark fir, Alpine fir, and white fir. Found in mixtures with douglas fir, engelmann spruce, lodgepole pine and ponderosa pine. It is found at varying elevations, depending upon exposure, within the douglas fir and engelmann spruce zones, and at times in the ponderosa pine type.

Subalpine (Alp)

A stand containing a varying mixture of subalpine species, no one of which is abundant enough to place the stand into any of the foregoing

types. At the upper limit of tree growth, usually unmerchantable because of poor form and small size, and of value for protective purposes only. The principal species are alpine fir, engelmann spruce, lodgepole pine, limber pine, bristlecone pine and dwarf juniper.

Aspen (A)

A stand containing approximately 60% or more of aspen, often nearly pure, but sometimes with the regional conifers or hardwoods in mixture. It occurs at medium to high elevations and usually on fairly moist sites. Even when aspen forms a nearly pure overstory, conifers or tolerant hardwoods are often abundant as reproduction underneath. Such stands may be mapped as young age classes of this understory. The understory may be shown by use of the standard symbols together with the standard color for aspen.

In Colorado and Utah the understory may be of engelmann spruce, blue spruce, alpine fir, douglas fir, ponderosa pine, white fir, or more rarely lodgepole pine. In Arizona and New Mexico the understory may be of engelmann spruce, cork-bark fir, and alpine fir, which indicates a permanent type of spruce, or of douglas fir and white fir, which indicates a permanent douglas fir type.

Miscellaneous Hardwood (Hwd)

A stand composed of a mixture of species or of pure stands of hardwoods existing along river courses or in arroyos at the lower elevations where moisture is relatively abundant.

Protection Types

Protection types are normally thought of as forest types on watersheds which for one reason or another are listed as non-use areas. Usually non-use is recommended to prevent soil erosion and to protect as well as produce the maximum water for towns and cities, or for irrigation use.

In considering types it seems best not to use the protection type classification. All forest stands should be considered as protective cover and use made of the area will of necessity vary according to local conditions. On S.C.S. surveys, types should be classified according to cover on the area. Unmerchantable stands should be indicated by the proper symbols and areas closed to all use may be indicated by appropriate symbols also but will not be called protection types. If color is used to indicate non-use vegetative type should be shown by letter symbols.

The protection of soil and water resources as well as of all resources, should be considered on all types. Factors such as slope, present cover, soil, rainfall, etc., will be considered on each area and the surveyor will make his recommendations for use only after such factors have been carefully considered. On the use map an area needing full protection or non-use can be indicated. The present condition should be indicated and present use recommended of all types. An area classified

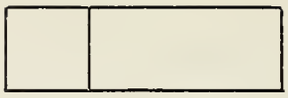
as a non-use area might, after a few years' protection, be capable of producing some forest products which could be used without deterioration of the site or adverse effects on water production. Experiments have shown that a non-managed virgin pine forest does not produce the maximum usable water. In fact available data at present indicate that a pine forest managed on the shortest possible rotation is best from a water production standpoint, and in many cases watersheds closed from all commercial use in the interest of water users might better be handled as a forest enterprise with proper safeguards to give the maximum usable water.

SOIL CONSERVATION SERVICE
COLOR LEGEND

Color No.				Dixon's Best Pencil
1S	40 drops	Canary Yellow		353½
1T	60 "	Brilliant Yellow	grass	353
2	80 "	Cadmium Orange	aspen	324
3	60 "	Crimson Lake	cultivated	321½ light
4	40 "	Stone Brown	sagebrush	343
5	40 "	Olive Green	brush (browse)	354½
6	40 "	Dark Green	limber pine	325
7	60 "	Sea Green	ponderosa pine	354 light
9	80 "	Light Green	pinon-juniper	325 light
10	40 "	Rose Pink	Misc. hardwoods	322
11	40 "	Bottle Green	pinon	354 dark
12	40 "	Yellow Earth	mesquite	335½
13	40 "	Stone Gray	juniper	352½
14	60 "	Royal Purple	oak	323 dark
15	40 "	Light Tan	Douglas fir	335
16	100 "	Deep Tan	White fir	343
17	40 "	Wistaria Violet	E. spruce	323 light
18	80 "	Terra Cotta Red		351
19	30 "	Sky Blue	water	320 light
20	150 "	Sky Blue	non-use types	320 dark
21	30 "	Lamp Black	burn	352½
22	200 "	Carmine	alpine fir	321½
23	30 "	Yellow Ochre		324½
24	150 "	Emerald Green	Lodgepole pine	354½

Mixture based on Japanese Water Color & one ounce water.

L-921-A



Barren

Timber-Woodland mixture. Use color for predominate species. Cross hatching to be in black.

Planting recommended.

AGE CLASS SYMBOLS

Where it is desirable to show age classes, this may be done by using species and age class symbols with dots in the species color to show young or unmerchantable age or size classes. In the example given below Douglas fir has been used as an illustration.

DF-S
0-40

Saplings, S. Age 0-40 years usually under 4". Species to be dotted in with fine dots.

DF-Po
40-80

Poles, P. Age 40-80 years usually 4" to 8" D.B.H. Species to be dotted in with slightly larger dots.

DF-IU
80-120

Intermediate Unmerchantable, I.U. 80-120 Years, usually 8" to 12" D.B.H. without sufficient material of merchantable size to form the basis of a logging operation.

DF-IM
80-120

Intermediate Merchantable, I.M. 80-120 years usually 8" to 12" D.B.H. I.M. will mean intermediate merchantable and that the stand in this age class contains sufficient material of a merchantable size to be available from a logging point of view.

BF-MM
120-160

Mature, M. 120-160 years.
M.M. will mean mature merchantable.
M.U. will mean unmerchantable.

DF-OM
160-200

Overmature, O.M. 160 years and over.
O.M.M. will mean overmature merchantable.
O.M.U. will mean overmature unmerchantable.

SURVEY WORK PLAN

Before making a work plan, it is necessary to make a preliminary examination of the area to be surveyed as otherwise it is not possible to establish a need for a survey or to determine the type of information desired. As an example, this preliminary survey may indicate that it is only necessary to determine the location of old and defective stands that need prompt attention or it may establish a need for complete information on volume, growth and condition as a basis for regulation, utilization, protection and silvicultural improvement of the stand. In a preliminary examination, the following might be noted.

1. Areas apparently available for different uses.

2. General location and extent of forest types located roughly on a map.

3. Height, diameter and quality range of the species on the area.

The work plan for the survey decided upon should cover the where, when, why, and how of the survey. A sample outline is given below.

SURVEY WORK PLAN OUTLINE

I. Area to be surveyed.

- A. Ownership
- B. Location
- C. General description of area
  - 1. Size of area.
  - 2. Type of timber involved.
    - a. Species
    - b. Condition
  - 3. Topography
  - 4. General market conditions.

II. Purpose of survey.

- A. Silvicultural management and erosion control.
- B. Regulation
  - 1. Products
- C. Plans or wishes of landowner.

III. Intensity and type of data required.

A. Intensity of survey proposed.

B. Mapping needs or standards.

C. Type of growth, volume and standard data required.

IV. Survey procedure or methods to be employed.

A. Mapping (field and office)

B. Controls

C. Estimating

D. Crew organization

1. Personnel

2. Duties

E. Method of eliminating unmerchantable and non-timber types from intensive estimate.

F. Growth data.

G. Volume measurements and tables.

H. Records and forms.

V. Cost estimates.

A. Coverage per man day.

1. Man days.

2. Rate

3. Cost

B. Per diem

C. Equipment

D. Transportation

SURVEY REPORT OUTLINE - (SAMPLE)

I. Name and location.

Ownership of property.

Location of property.

A. Legal description.

(1) Plat of area.

B. General location - skeleton map showing location in relation to other areas, marketing facilities and transportation systems if desired.

II. Dates of survey.

III. Area covered by survey.

A. Tabular.

B. Compartment type maps.

IV. Compartment summaries.

A. Total area by compartment.

B. Merchantable area by types and compartments.

C. Net volume by species, type and compartments (indicate volume tables used).

(1) Show by cut and leave if cruised by that system.

(2) Volume of special products such as post.

(3) Volume per acre.

D. Method of determining defect (brief).

V. Growth

VI. Silvical descriptions (brief).

A. Forest types.

B. Age classes.

C. Size and quality of timber.

D. Damage

E. Defect

VII. Protection

VIII. Logging and appraisal data.

A. Seasons of work.

B. Transportation systems and conditions.

C. Market conditions.

IX. Appendix*

A. History and personnel of projects.

B. Sampling percentage and method (check estimate).

C. Compilation of costs.

* The survey report may vary in length and detail, depending on coverage in the survey work plan and timber management plan. If the work plan is filed with the survey report, some of the items in the above sample outline will be adequately covered there. Also if the management plan is made immediately, some of the items will be covered in the plan. A report outline should be made up to fit the conditions at hand.

ADVANTAGES OF THE LINE-SAMPLE-PLOT METHOD

(1) If the line is chained, the sample plots are located without bias, and the location of each plot is determined exactly. Consequently, if an intensive cruise is made a reliable representation of all the forest conditions is obtained.

(2) The center of each plot can be definitely marked by the compassman.

(3) The estimator is not hindered by brush and windfalls and other obstacles to the same extent as in strip cruising.

(4) The cruiser can have the compassman tally the timber, measure diameters, or measure out to line trees, regardless of what method is used to determine volume on the plot. This means that the cruiser can devote more time to sizing up diameters and heights of trees than he ordinarily could if using the strip system.

(5) The area of the plot can be determined more accurately than that of a strip, because it is entirely feasible to measure out with tape in any direction from the center of the plot, which is definitely fixed, and determine whether a tree is in or out.

(6) If a stake is set to designate the center of the plot, the checker is certain to take exactly the same trees as the original cruiser. For this reason, the sample-plot system permits a definite and detailed check that is practically certain to reveal any error made by the original cruiser. Strip cruising does not do this unless the center line is definitely marked.

(7) A separate record can be kept of each plot. It is then possible to group plots by forest type and condition, and to re-assemble the estimates by section, logging unit, and other land divisions and by cover type.

(8) If the volume estimate for each plot is kept separate the variation from place to place in stand per acre can be shown on the map, which is not practicable if the ordinary strip-cruising method is used.

(9) Cull and breakage can be determined more accurately, because the cruiser has a better opportunity to study the trees and size up all the conditions affecting net volume. Also, he can carefully size up the timber between plots, because he does not have to tally any timber between plots.

(10) Both diameter and merchantable height can be determined more accurately. In ordinary timber the trees near the outside of a 1/4-acre plot are about the right distance away from the center of the plot for sizing up heights.

(11) If distances are paced, errors in pacing do not materially affect the accuracy of the cruise, because the necessary number of plots are taken regardless of such errors.

(12) The method can be used to good advantage by a man working alone.

(13) The data taken lend themselves to statistical analysis, if plot volumes are kept separate.

Table of Coverage by
Number and Size of Plots

Size of Plot in Acres	Distance Between Plots	No. Strips Per 640 Acres							
		1	2	3	4	5	6	7	8
0.1	5 ch.	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00
0.1	10 ch.	0.125	0.25	0.375	0.50	0.625	0.75	0.875	1.00
0.1	20 ch.	0.063	0.125	0.188	0.25	0.313	0.375	0.438	0.500
0.25	5 ch.	0.625	1.25	1.875	2.50	3.125	3.750	4.375	5.00
0.25	10 ch.	0.313	0.625	0.938	1.25	1.563	1.875	2.188	2.50
0.25	20 ch.	0.157	0.313	0.469	0.625	0.787	0.938	1.094	1.25
0.5	5 ch.	1.25	2.50	3.75	5.00	6.25	7.50	8.75	10.00
0.5	10 ch.	0.625	1.25	1.875	2.50	3.125	3.75	4.275	5.00
0.5	20 ch.	0.313	0.625	0.938	1.25	1.563	1.875	2.138	2.50
1.0	5 ch.	2.5	5.0	7.5	10.0	12.5	15.00	17.50	20.00
1.0	10 ch.	1.25	2.5	3.75	5.0	6.25	7.50	8.75	10.00
1.0	20 ch.	0.625	1.25	1.875	2.50	3.125	3.75	4.375	5.00

CONVERSION EQUIVALENTS

Length and Distance

1 foot = 12 inches = 0.3333 yard = 0.06061 rod = 0.01515 chain (s) = 0.0001894 mile = 0.3048 meter.

1 inch = 0.08333 foot = 0.02778 yard = 2.540 centimeters.

1 chain (surveyor's) = 66 feet = 4 rods = 100 links = 0.0125 mile = 20.1168 meters.

1 link = 7.92 inches = 0.66 foot.

1 rod = 16.5 feet = 5.5 yards = 25 links = 0.25 chain (s) = 0.003125 mile

1 yard = 3 feet = 36 inches = 0.914402 meter.

1 mile = 63,360 inches = 8,000 links = 5,280 feet = 1,760 yards = 320 rods = 80 chains (s) = 1.60935 kilometers.

Area

1 sq. ft. = 144 sq. in. = 0.1111 sq. yd. = 0.0929034 sq. meter.

1 sq. mile = 27,878,400 sq. ft. = 3,097,600 sq. yds. = 640 acres = 1 section = 259 hectares = 2.59 sq. kilometers.

(From "Timber Cruising" by James W. Girard and Suren R. Goverkiantz.)

Plot Dimensions

1 acre. Side of square = 208.71 feet = 3.162 chains (s) = 12.65 rods.
Radius of circle = 117.75 feet = 1.784 chains (s) = 7.14 rods.

1/2 acre. Side of square = 147.57 feet = 2.236 chains (s) = 8.94 rods.
Radius of circle = 83.26 feet = 1.262 chains (s) = 5.05 rods.

1/4 acre. Side of square = 104.35 feet = 1.581 chains (s) = 6.32 rods.
Radius of circle = 58.88 feet = 0.892 chain (s) = 3.57 rods.

1/5 acre. Side of square = 93.34 feet = 1.414 chains (s) = 5.66 rods.
Radius of circle = 52.66 feet = 0.798 chain (s) = 3.19 rods.

1/10 acre. Side of square = 66 feet = 1 chain (s) = 4 rods. Radius of circle = 37.24 feet = 0.564 chain (s) = 2.26 rods.

1/40 acre. Side of square = 1/2 chain (s) = 33 feet. Radius of circle = 18.62 feet = 0.282 chain (s) = 1.13 rods.

1/160 acre. Side of square = 1/4 chain (s) = 16-1/2 feet. Radius of circle = 9.31 feet = 0.141 chain (s) = 0.564 rod.

Surveyor's Square Measure

1 acre = 43,560 square feet = 4,840 square yards = 160 square rods = 10 square chains (s) = 4,046.87 square meters = 0.404687 hectare.

1 section = 1 square mile = 640 acres = 16 forties = 102,400 square rods = 3,097,600 square yards = 259 hectares.

1 township = 36 sections = 23,040 acres.

Volume

1 cubic foot = 1,728 cubic inches = 0.028317 cubic meter.

1 cubic yard = 46,656 cubic inches = 27 cubic feet = 0.76456 cubic meter.

1 cubic meter = 35.3145 cubic feet = 61,023.5 cubic inches = 1.30794 cu.yds.

1 cubic foot per acre = 0.06997 cubic meter per hectare.

1 cubic meter per hectare = 14.2913 cubic feet per acre.

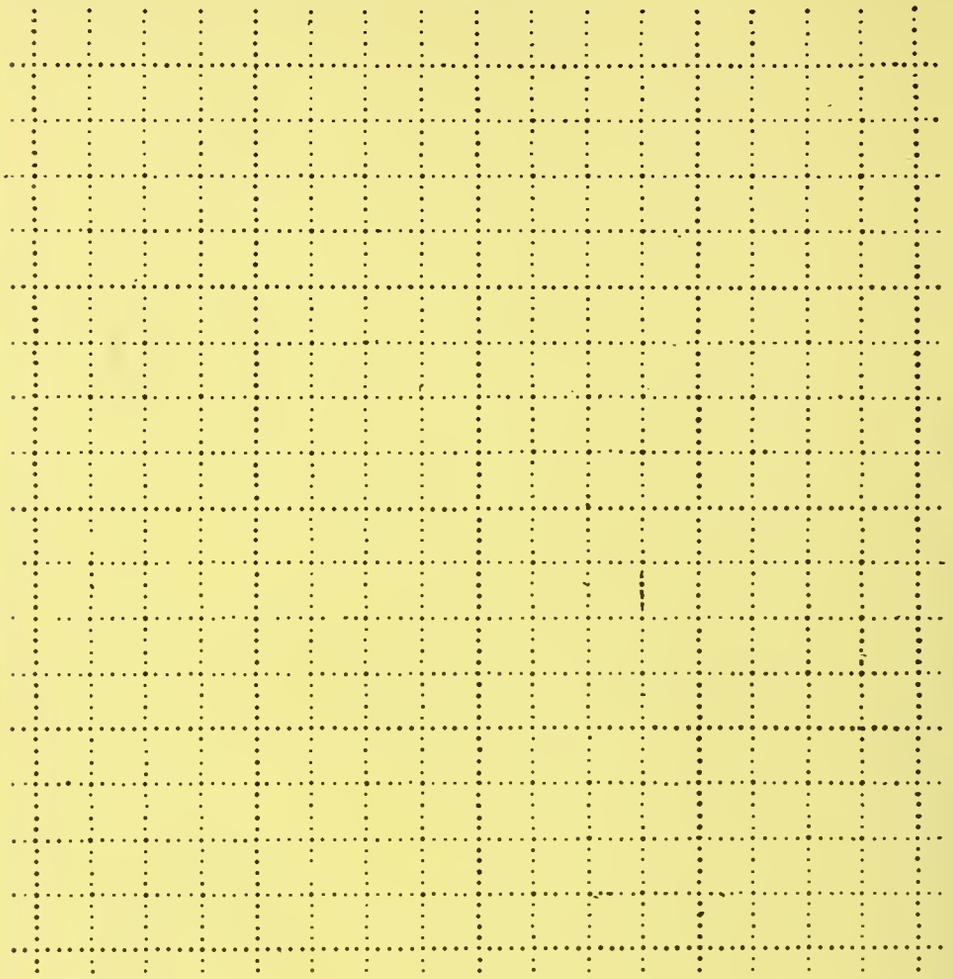
(From "Timber Cruising" by James W. Girard and Suren R. Gevorkiantz.)

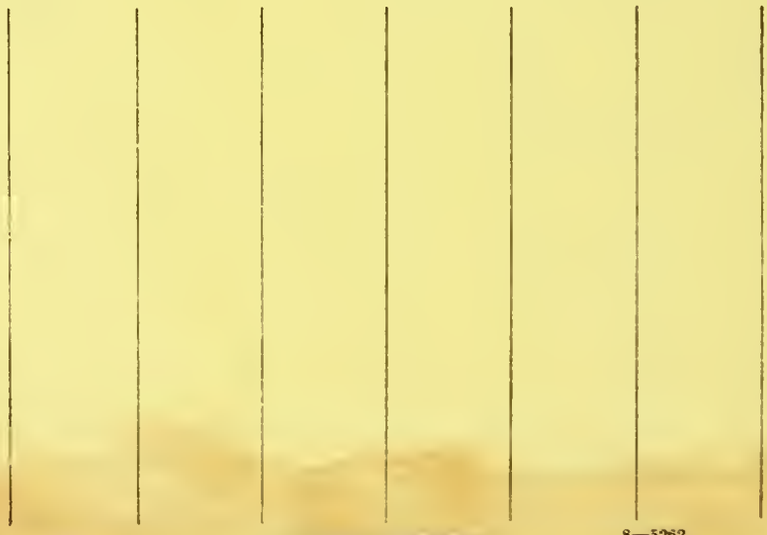
Form 493

MAP SHEET

COMPASSMAN_____

T.____R.____SEC.____MER._____DATE_____19___





GOVERNMENT PRINTING OFFICE 8—5262

SAW TIMBER ESTIMATE SHEET

T.____ R.____ Sec.___ Mer.____ Forty ____ Plot No.___
Location _____ Sheet No. ___
Quadrangle _____ Photo No. _____ Date _____
Area _____ Acres _____ Estimator _____
Type _____ Aspect _____ Slope _____% Elev.____

Type ____ Age Class ___	Species-Reprod				Total
	Number per Milacre				

Dead	Cull	Tot.	Species Cut			Species Leave			Tot.Vol. or Number
			4						
			6						
			8						
			10						
			D	Log Lengths	Vol.		Log Lengths	Vol.	
			12						
			14						
			16						
			18						
			20						
			22						
			Tot						

SUMMARY

Species					

Reproduction is material below 4" d.b.h.

Dead	Cull	Tot.	Species Cut								Species Leave								Tot. Vol. or Number
			4																
			6																
			8																
			10																
			D	Log Lengths						Vol.		Log Lengths						Vol.	
			12																
			14																
			16																
			18																
			20																
			22																
			Tot																

Dead	Cull	Tot.	Species Cut								Species Leave								Tot. Vol. or Number
			4																
			6																
			8																
			10																
			D	Log Lengths						Vol		Log Lengths						Vol	
			12																
			14																
			16																
			18																
			20																
			22																
			Tot																

Form 494—R. 4b

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

T. 17 S
R. 17 E
Sec. 14
From Sta. 107 A
Direction N

Sheet No. 1
Mill Creek
(Logging unit)
Type D.F
Age Class 120-160

John Doe, Compassman.
John Doe, Estimator.
8/1/40 Date.

SPECIES	D F			L.F.								
PLOT	CUT	LEAVE		CUT	LEAVE		CUT	LEAVE		CUT	LEAVE	
NO. 1	24-5::	10x:·	13	12-2								
SITE	20-4·:	8::	4									
MER. CL. 10M	16-3·:	6:	2									
ACT. AGE 155		4:	2									
REP. P												
PLOT EST.	3580			90								
NO.												
SITE												
MER. CL.												
ACT. AGE												
REP.												
PLOT EST.												
NO.												
SITE												
MER. CL.												
ACT. AGE												
REP.												
PLOT EST.												
NO.												
SITE												
MER. CL.												
ACT. AGE												
REP.												
PLOT EST.												
SHEET SUMMARY												

U. S. GOVERNMENT PRINTING OFFICE: 1931 8—5852

24-5:: = Four 5 log 24 inch trees.

Form 494
(Revised 1916)

Check 40 which this sheet represents, showing course by →

T _____ Sheet No. _____

R _____ Ht. Class _____ _____ Compassman

S _____ _____ Estimator

40 _____ _____ Date

_____M Logging Unit _____ Site

D. B. H.										
Vol. on strip										
Cull %										
Vol. on strip net										
Vol. on 40										
No. logs on 40										
No. trees on 40										

Snags over _____ inches D. B. H. and _____ feet high _____

Average stand per acre= _____

8—2406

Forest Service Form - Available at the Regional office.

WOODLAND TALLY SHEET

Strip _____ Plot _____ Date _____
Size Plot _____ T. _____ R. _____ Sec. _____
Type _____ Unit _____ Estimator _____
Photo No. _____ Use _____
Aspect _____ Slope _____ % Cover _____
Damage _____
Erosion _____

D	Crown Width							Species		
H	5	10	15	20	25	30		Posts	Rep.	Dead
2										
4										
6										
8										
10										

D	Crown Width							Species		
H	5	10	15	20	25	30		Posts	Rep.	Dead
2										
4										
6										
8										
10										

D	Pieces - 4-Foot						Species				
H	1	2	3	4	5	6	7	8	9	10	11
2											
4											
6											
8											
10											

	Pieces - 4-Foot							Species		
								Rep.	Dead	Poles

SUMMARY - Per Acre

Species	Dead	Green	Total	Posts	
Totals					

POST ESTIMATE FORM

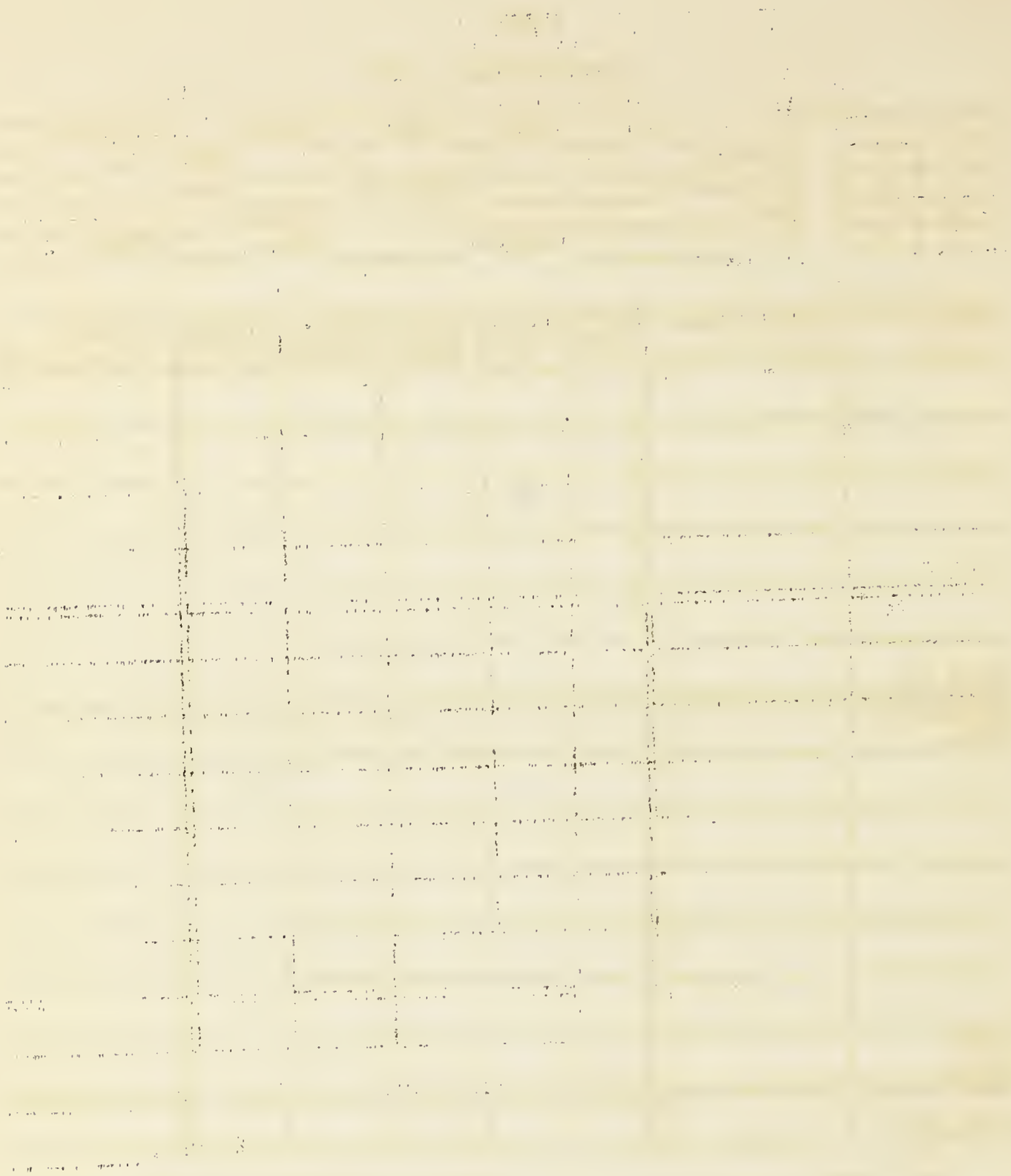
T. _____ R. _____ Sec. _____ Mer. _____ Forty _____ Plot No. _____
Location _____ Sheet No. _____
Quadrangle _____ Photo No. _____ Date _____
Area _____ Acres. Estimator _____
Type _____ Aspect _____ Slope _____ % Elev. _____

Species to Cut	Corner Posts Top 5" & over	6½" Posts by Top Diameter Classes: 4"	3"	2½-3"	2"-2½	1"-2"	Reprod. below 1" top
Total Cut							
Species to Leave							
Total Leave							
Plot Total							

Total Cut: _____ Posts available in 10 yrs. _____

Leave: _____ in 20 yrs. _____

Note: This form is suggestive only and variations will be needed to cover localities where posts grow more than ½ inch in top diameter in 10 years time.



Pinon Juniper Estimate Sheet

One encounters so many variations in use and condition within the pinon-juniper and transition types that it is difficult to prepare a form to cover all contingencies. There will be little opportunity to make cruises to determine volume of fuel wood on privately owned lands and such cruises will largely be limited to L.U. areas and grants under conditions where the need for volume regulation is apparent.

In cruising pinon it is suggested that this species be entered in the tally by D.B.H., no. of 4 foot pieces, no. trees and volume. For juniper a record should be kept of trees partially and fully cut and similar data procured for pinon. A summation of these data compared to the present stand will give a fair picture of past use.

Volume Tables

Insert where applicable:

1. Volume Tables for Juniperus Monosperma and Juniperus Scopulorum by Howell and Lexen. Regional Bulletin No. 59, Woodland Series No. 8. 1939

2. Volume Table for Pinus edulis. Supplement No. 1 to Regional Bulletin No. 59, Woodland Series No. 8. 1939

3. Merchantable Height Volume Table for Immature Ponderosa Pine. Research Note No. 73. Southwestern Forest and Range Experiment Station. 1939

4. Merchantable Height Volume Table for Mature Ponderosa Pine. Research Note No. 74. Southwestern Forest and Range Experiment Station. 1939.

5. Merchantable Height Volume Table for Ponderosa Pines. Research Note No. 75. Southwestern Forest and Range Experiment Station. 1939.

6. Other volume tables as needed.

TABLE OF SQUARES

	0	1	2	3	4	5	6	7	8	9
0	0	1	4	9	16	25	36	49	64	81
1	100	121	144	169	196	225	256	289	324	361
2	400	441	484	529	576	625	676	729	784	841
3	900	961	1024	1089	1156	1225	1296	1369	1444	1521
4	1600	1681	1764	1849	1936	2025	2116	2209	2304	2401
5	2500	2601	2704	2809	2916	3025	3136	3249	3364	3481
6	3600	3721	3844	3969	4096	4225	4356	4489	4624	4761
7	4900	5041	5184	5329	5476	5625	5776	5929	6084	6241
8	6400	6561	6724	6889	7056	7225	7396	7569	7744	7921
9	8100	8281	8464	8649	8836	9025	9216	9409	9604	9801
10	10000	10201	10404	10609	10816	11025	11236	11449	11664	11881
11	12100	12321	12544	12769	12996	13225	13456	13689	13924	14161
12	14400	14641	14884	15129	15376	15625	15876	16129	16384	16641
13	16900	17161	17424	17689	17956	18225	18496	18769	19044	19321
14	19600	19881	20164	20449	20736	21025	21316	21609	21904	22201
15	22500	22801	23104	23409	23716	24025	24336	24649	24964	25281
16	25600	25921	26244	26569	26896	27225	27556	27889	28224	28561
17	28900	29241	29584	29929	30276	30625	30976	31329	31684	32041
18	32400	32761	33124	33489	33856	34225	34596	34969	35344	35721
19	36100	36481	36864	37249	37636	38025	38416	38809	39204	39601
20	40000	40401	40804	41209	41616	42025	42436	42849	43264	43681
21	44100	44521	44944	45369	45796	46225	46656	47089	47524	47961
22	48400	48841	49284	49729	50176	50625	51076	51529	51984	52441
23	52900	53361	53824	54289	54756	55225	55696	56169	56644	57121
24	57600	58081	58564	59049	59536	60025	60516	61009	61504	62001
25	62500	63001	63504	64009	64516	65025	65536	66049	66564	67081
26	67600	68121	68644	69169	69696	70225	70756	71289	71824	72361
27	72900	73441	73984	74529	75076	75625	76176	76729	77284	77841
28	78400	78961	79524	80089	80656	81225	81796	82369	82944	83521
29	84100	84681	85264	85849	86436	87025	87616	88209	88804	89401
30	90000	90601	91204	91809	92416	93025	93636	94249	94864	95481
31	96100	96721	97344	97969	98596	99225	99856	100489	101124	101761
32	102400	103041	103684	104329	104976	105625	106276	106929	107584	108241
33	108900	109561	110224	110889	111556	112225	112896	113569	114244	114921
34	115600	116281	116964	117649	118336	119025	119716	120409	121104	121801
35	122500	123201	123904	124609	125316	126025	126736	127449	128164	128881
36	129600	130321	131044	131769	132496	133225	133956	134689	135424	136161
37	136900	137641	138384	139129	139876	140625	141376	142129	142884	143641
38	144400	145161	145924	146689	147456	148225	148996	149769	150544	151321
39	152100	152881	153664	154449	155236	156025	156816	157609	158404	159201
40	160000	160801	161604	162409	163216	164025	164836	165649	166464	167281
41	168100	168921	169744	170569	171396	172225	173056	173889	174724	175561
42	176400	177241	178084	178929	179776	180625	181476	182329	183184	184041
43	184900	185761	186624	187489	188356	189225	190096	190969	191844	192721
44	193600	194481	195364	196249	197136	198025	198916	199809	200704	201601
45	202500	203401	204304	205209	206116	207025	207936	208849	209764	210681
46	211600	212521	213444	214369	215296	216225	217156	218089	219024	219961
47	220900	221841	222784	223729	224676	225625	226576	227529	228484	229441
48	230400	231361	232324	233289	234256	235225	236196	237169	238144	239121
49	240100	241081	242064	243049	244036	245025	246016	247009	248004	249001
50	250000	251001	252004	253009	254016	255025	256036	257049	258064	259081

Table of Squares Cont'd

	0	1	2	3	4	5	6	7	8	9
51	260100	261121	262144	263169	264196	265225	266256	267289	268324	269361
52	270400	271441	272484	273529	274576	275625	276676	277729	278784	279841
53	280900	281961	283024	284089	285156	286225	287296	288369	289444	290521
54	291600	292681	293764	294849	295936	297025	298116	299209	300304	301401
55	302500	303601	304704	305809	306916	308025	309136	310249	311364	312481
56	313600	314721	315844	316969	318096	319225	320356	321489	322624	323761
57	324900	326041	327184	328329	329476	330625	331776	332929	334084	335241
58	336400	337561	338724	339889	341056	342225	343396	344569	345744	346921
59	348100	349281	350464	351649	352836	354025	355216	356409	357604	358801
60	360000	361201	362404	363609	364816	366025	367236	368449	369664	370881
61	372100	373321	374544	375769	376996	378225	379456	380689	381924	383161
62	384400	385641	386884	388129	389376	390625	391876	393129	394384	395641
63	396900	398161	399424	400689	401956	403225	404496	405769	407044	408321
64	409600	410881	412164	413449	414736	416025	417316	418609	419904	421201
65	422500	423801	425104	426409	427716	429025	430336	431649	432964	434281
66	435600	436921	438244	439569	440896	442225	443556	444889	446224	447561
67	448900	450241	451584	452929	454276	455625	456976	458329	459684	461041
68	462400	463761	465124	466489	467856	469225	470596	471969	473344	474721
69	476100	477481	478864	480249	481636	483025	484416	485809	487204	488601
70	490000	491401	492804	494209	495616	497025	498436	499849	501264	502681
71	504100	505521	506944	508369	509796	511225	512656	514089	515524	516961
72	518400	519841	521284	522729	524176	525625	527076	528529	529984	531441
73	532900	534361	535824	537289	538756	540225	541696	543169	544644	546121
74	547600	549081	550564	552049	553536	555025	556516	558009	559504	561001
75	562500	564001	565504	567009	568516	570025	571536	573049	574564	576081
76	577600	579121	580644	582169	583696	585225	586756	588289	589824	591361
77	592900	594441	595984	597529	599076	600625	602176	603729	605284	606841
78	608400	609961	611524	613089	614656	616225	617796	619369	620944	622521
79	624100	625681	627264	628849	630436	632025	633616	635209	636804	638401
80	640000	641601	643204	644809	646416	648025	649636	651249	652864	654481
81	656100	657721	659344	660969	662596	664225	665856	667489	669124	670761
82	672400	674041	675684	677329	678976	680625	682276	683929	685584	687241
83	688900	690561	692224	693889	695556	697225	698896	700569	702244	703921
84	705600	707281	708964	710649	712336	714025	715716	717409	719104	720801
85	722500	724201	725904	727609	729316	731025	732736	734449	736164	737881
86	739600	741321	743044	744769	746496	748225	749956	751689	753424	755161
87	756900	758641	760384	762129	763876	765625	767376	769129	770884	772641
88	774400	776161	777924	779689	781456	783225	784996	786769	788544	790321
89	792100	793881	795664	797449	799236	801025	802816	804609	806404	808201
90	810000	811801	813604	815409	817216	819025	820836	822649	824464	826281
91	828100	829921	831744	833569	835396	837225	839056	840889	842724	844561
92	846400	848241	850084	851929	853776	855625	857476	859329	861184	863041
93	864900	866761	868624	870489	872356	874225	876096	877969	879844	881721
94	883600	885481	887364	889249	891136	893025	894916	896809	898704	900601
95	902500	904401	906304	908209	910116	912025	913936	915849	917764	919681
96	921600	923521	925444	927369	929296	931225	933156	935089	937024	938961
97	940900	942841	944784	946729	948676	950625	952576	954529	956484	958441
98	960400	962361	964324	966289	968256	970225	972196	974169	976144	978121
99	980100	982081	984064	986049	988036	990025	992016	994009	996004	998001
100	1000000	1002001	1004004	1006009	1008016	1010025	1012036	1014049	1016064	1018081

TABLE OF SQUARE ROOTS

	0	1	2	3	4	5	6	7	8	9
0	0	1.0000	1.4142	1.7321	2.0000	2.2361	2.4495	2.6458	2.8284	3.0000
1	3.1623	3.3166	3.4641	3.6056	3.7417	3.8730	4.0000	4.1231	4.2426	4.3589
2	4.4721	4.5826	4.6904	4.7958	4.8990	5.0000	5.0990	5.1962	5.2915	5.3852
3	5.4772	5.5678	5.6569	5.7446	5.8310	5.9161	6.0000	6.0828	6.1644	6.2450
4	6.3246	6.4031	6.4807	6.5574	6.6332	6.7082	6.7823	6.8557	6.9282	7.0000
5	7.0711	7.1414	7.2111	7.2801	7.3485	7.4162	7.4833	7.5498	7.6158	7.6811
6	7.7460	7.8102	7.8740	7.9373	8.0000	8.0623	8.1240	8.1854	8.2462	8.3066
7	8.3666	8.4261	8.4853	8.5440	8.6023	8.6603	8.7178	8.7750	8.8318	8.8882
8	8.9443	9.0000	9.0554	9.1104	9.1652	9.2195	9.2736	9.3274	9.3808	9.4340
9	9.4868	9.5394	9.5917	9.6437	9.6954	9.7468	9.7980	9.8489	9.8995	9.9499
10	10.0000	10.0499	10.0995	10.1489	10.1980	10.2470	10.2956	10.3441	10.3923	10.4403
11	10.4881	10.5357	10.5830	10.6301	10.6771	10.7238	10.7703	10.8167	10.8628	10.9087
12	10.9545	11.0000	11.0454	11.0905	11.1355	11.1803	11.2250	11.2694	11.3137	11.3578
13	11.4018	11.4455	11.4891	11.5326	11.5758	11.6190	11.6619	11.7047	11.7473	11.7898
14	11.8322	11.8743	11.9164	11.9583	12.0000	12.0416	12.0830	12.1244	12.1655	12.2066
15	12.2474	12.2882	12.3288	12.3693	12.4097	12.4499	12.4900	12.5300	12.5698	12.6095
16	12.6491	12.6886	12.7279	12.7671	12.8062	12.8452	12.8841	12.9228	12.9615	13.0000
17	13.0384	13.0767	13.1149	13.1529	13.1909	13.2288	13.2665	13.3041	13.3417	13.3791
18	13.4164	13.4536	13.4907	13.5277	13.5647	13.6015	13.6382	13.6748	13.7113	13.7477
19	13.7840	13.8203	13.8564	13.8924	13.9284	13.9642	14.0000	14.0357	14.0712	14.1067
20	14.1421	14.1774	14.2127	14.2478	14.2829	14.3178	14.3527	14.3875	14.4222	14.4568
21	14.4914	14.5258	14.5602	14.5945	14.6287	14.6629	14.6969	14.7309	14.7648	14.7986
22	14.8324	14.8661	14.8997	14.9332	14.9666	15.0000	15.0333	15.0665	15.0997	15.1327
23	15.1658	15.1987	15.2315	15.2643	15.2971	15.3297	15.3623	15.3948	15.4272	15.4596
24	15.4919	15.5242	15.5563	15.5885	15.6205	15.6525	15.6844	15.7162	15.7480	15.7797
25	15.8114	15.8430	15.8745	15.9060	15.9374	15.9687	16.0000	16.0312	16.0624	16.0935
26	16.1245	16.1555	16.1864	16.2173	16.2481	16.2788	16.3095	16.3401	16.3707	16.4012
27	16.4317	16.4621	16.4924	16.5227	16.5529	16.5831	16.6132	16.6433	16.6733	16.7033
28	16.7332	16.7631	16.7929	16.8226	16.8523	16.8819	16.9115	16.9411	16.9706	17.0000
29	17.0294	17.0587	17.0880	17.1172	17.1464	17.1756	17.2047	17.2337	17.2627	17.2916
30	17.3205	17.3494	17.3781	17.4069	17.4356	17.4642	17.4929	17.5214	17.5499	17.5784
31	17.6068	17.6352	17.6635	17.6918	17.7200	17.7482	17.7764	17.8045	17.8326	17.8606
32	17.8885	17.9165	17.9444	17.9722	18.0000	18.0278	18.0555	18.0831	18.1108	18.1384
33	18.1659	18.1934	18.2209	18.2483	18.2757	18.3030	18.3303	18.3576	18.3848	18.4120
34	18.4391	18.4662	18.4932	18.5203	18.5472	18.5742	18.6011	18.6279	18.6548	18.6815
35	18.7083	18.7350	18.7617	18.7883	18.8149	18.8414	18.8680	18.8944	18.9209	18.9473
36	18.9737	19.0000	19.0263	19.0526	19.0788	19.1050	19.1311	19.1572	19.1833	19.2094
37	19.2354	19.2614	19.2873	19.3132	19.3391	19.3649	19.3907	19.4165	19.4422	19.4679
38	19.4936	19.5192	19.5448	19.5704	19.5959	19.6214	19.6469	19.6723	19.6977	19.7231
39	19.7484	19.7737	19.7990	19.8242	19.8494	19.8746	19.8997	19.9249	19.9499	19.9750
40	20.0000	20.0250	20.0499	20.0749	20.0998	20.1246	20.1494	20.1742	20.1990	20.2237
41	20.2485	20.2731	20.2978	20.3224	20.3470	20.3715	20.3961	20.4206	20.4450	20.4695
42	20.4939	20.5183	20.5426	20.5670	20.5913	20.6155	20.6398	20.6640	20.6882	20.7123
43	20.7364	20.7605	20.7846	20.8087	20.8327	20.8567	20.8806	20.9045	20.9284	20.9523
44	20.9762	21.0000	21.0238	21.0476	21.0713	21.0950	21.1187	21.1424	21.1660	21.1896
45	21.2132	21.2368	21.2603	21.2838	21.3073	21.3307	21.3542	21.3776	21.4009	21.4243
46	21.4476	21.4709	21.4942	21.5174	21.5407	21.5639	21.5870	21.6102	21.6333	21.6564
47	21.6795	21.7025	21.7256	21.7486	21.7715	21.7945	21.8174	21.8403	21.8632	21.8861
48	21.9089	21.9317	21.9545	21.9773	22.0000	22.0227	22.0454	22.0681	22.0907	22.1133
49	22.1359	22.1585	22.1811	22.2036	22.2261	22.2486	22.2711	22.2935	22.3159	22.3383
50	22.3607	22.3830	22.4054	22.4277	22.4499	22.4722	22.4944	22.5167	22.5389	22.5610

Table of Square Roots Cont'd

	0	1	2	3	4	5	6	7	8	9
51	22.5831	22.6053	22.6274	22.6495	22.6715	22.6936	22.7156	22.7376	22.7596	22.7815
52	22.8035	22.8254	22.8473	22.8691	22.8910	22.9128	22.9346	22.9564	22.9782	23.0000
53	23.0217	23.0434	23.0651	23.0867	23.1084	23.1300	23.1516	23.1732	23.1948	23.2163
54	23.2379	23.2594	23.2808	23.3023	23.3238	23.3452	23.3666	23.3880	23.4093	23.4307
55	23.4520	23.4733	23.4946	23.5159	23.5372	23.5584	23.5796	23.6008	23.6220	23.6431
56	23.6643	23.6854	23.7065	23.7276	23.7486	23.7697	23.7907	23.8117	23.8327	23.8537
57	23.8746	23.8956	23.9165	23.9374	23.9582	23.9791	24.0000	24.0208	24.0416	24.0624
58	24.0831	24.1039	24.1246	24.1453	24.1660	24.1867	24.2074	24.2280	24.2487	24.2693
59	24.2899	24.3104	24.3310	24.3515	24.3721	24.3926	24.4131	24.4335	24.4540	24.4744
60	24.4948	24.5153	24.5356	24.5560	24.5764	24.5967	24.6170	24.6373	24.6576	24.6779
61	24.6981	24.7184	24.7386	24.7588	24.7790	24.7991	24.8193	24.8394	24.8596	24.8797
62	24.8997	24.9198	24.9399	24.9599	24.9799	25.0000	25.0199	25.0399	25.0599	25.0798
63	25.0998	25.1197	25.1396	25.1594	25.1793	25.1992	25.2190	25.2388	25.2586	25.2784
64	25.2982	25.3179	25.3377	25.3574	25.3771	25.3968	25.4165	25.4361	25.4558	25.4754
65	25.4950	25.5147	25.5342	25.5538	25.5734	25.5929	25.6124	25.6320	25.6515	25.6709
66	25.6904	25.7099	25.7293	25.7487	25.7681	25.7875	25.8069	25.8263	25.8456	25.8650
67	25.8843	25.9036	25.9229	25.9422	25.9615	25.9807	26.0000	26.0192	26.0384	26.0576
68	26.0768	26.0959	26.1151	26.1342	26.1533	26.1725	26.1916	26.2106	26.2297	26.2488
69	26.2678	26.2868	26.3058	26.3248	26.3438	26.3628	26.3818	26.4007	26.4196	26.4386
70	26.4575	26.4764	26.4952	26.5141	26.5329	26.5518	26.5706	26.5894	26.6082	26.6270
71	26.6458	26.6645	26.6833	26.7020	26.7207	26.7394	26.7581	26.7768	26.7955	26.8141
72	26.8328	26.8514	26.8700	26.8886	26.9072	26.9258	26.9443	26.9629	26.9814	27.0000
73	27.0185	27.0370	27.0554	27.0739	27.0924	27.1108	27.1293	27.1477	27.1661	27.1845
74	27.2029	27.2213	27.2396	27.2580	27.2763	27.2946	27.3130	27.3313	27.3495	27.3678
75	27.3861	27.4043	27.4226	27.4408	27.4590	27.4772	27.4954	27.5136	27.5317	27.5499
76	27.5680	27.5862	27.6043	27.6224	27.6405	27.6586	27.6767	27.6947	27.7128	27.7308
77	27.7488	27.7668	27.7848	27.8028	27.8208	27.8388	27.8567	27.8747	27.8926	27.9105
78	27.9284	27.9463	27.9642	27.9821	28.0000	28.0178	28.0356	28.0535	28.0713	28.0891
79	28.1069	28.1247	28.1424	28.1602	28.1780	28.1957	28.2134	28.2311	28.2488	28.2665
80	28.2842	28.3019	28.3196	28.3372	28.3548	28.3725	28.3901	28.4077	28.4253	28.4429
81	28.4604	28.4780	28.4956	28.5131	28.5306	28.5482	28.5657	28.5832	28.6006	28.6181
82	28.6356	28.6530	28.6705	28.6879	28.7054	28.7228	28.7402	28.7576	28.7749	28.7923
83	28.8097	28.8270	28.8444	28.8617	28.8790	28.8963	28.9136	28.9309	28.9482	28.9654
84	28.9827	29.0000	29.0172	29.0344	29.0516	29.0688	29.0860	29.1032	29.1204	29.1376
85	29.1547	29.1719	29.1890	29.2061	29.2232	29.2403	29.2574	29.2745	29.2916	29.3087
86	29.3257	29.3428	29.3598	29.3768	29.3938	29.4108	29.4278	29.4448	29.4618	29.4788
87	29.4957	29.5127	29.5296	29.5465	29.5634	29.5803	29.5972	29.6141	29.6310	29.6479
88	29.6647	29.6816	29.6984	29.7153	29.7321	29.7489	29.7657	29.7825	29.7993	29.8161
89	29.8328	29.8496	29.8663	29.8831	29.8998	29.9165	29.9332	29.9499	29.9666	29.9833
90	30.0000	30.0166	30.0333	30.0499	30.0665	30.0832	30.0998	30.1164	30.1330	30.1496
91	30.1662	30.1827	30.1993	30.2158	30.2324	30.2489	30.2654	30.2820	30.2985	30.3150
92	30.3315	30.3479	30.3644	30.3809	30.3973	30.4138	30.4302	30.4466	30.4630	30.4795
93	30.4959	30.5122	30.5286	30.5450	30.5614	30.5777	30.5941	30.6104	30.6267	30.6431
94	30.6594	30.6757	30.6920	30.7083	30.7245	30.7408	30.7571	30.7733	30.7896	30.8058
95	30.8220	30.8382	30.8544	30.8706	30.8868	30.9030	30.9192	30.9354	30.9515	30.9677
96	30.9838	31.0000	31.0161	31.0322	31.0483	31.0644	31.0805	31.0966	31.1126	31.1287
97	31.1448	31.1608	31.1769	31.1929	31.2089	31.2249	31.2409	31.2569	31.2729	31.2889
98	31.3049	31.3209	31.3368	31.3528	31.3687	31.3847	31.4006	31.4165	31.4324	31.4483
99	31.4642	31.4801	31.4960	31.5119	31.5277	31.5436	31.5594	31.5753	31.5911	31.6069
100	31.6227	31.6385	31.6543	31.6701	31.6859	31.7017	31.7175	31.7332	31.7490	31.7647

Table 43.-- Areas of circles (basal areas)

Diameter (full inches)	Area by additional fraction of inch of diameter									
	0.0 inch	0.1 inch	0.2 inch	0.3 inch	0.4 inch	0.5 inch	0.6 inch	0.7 inch	0.8 inch	0.9 inch
	Sq.ft.	Sq.ft.	Sq.ft.	Sq.ft.	Sq.ft.	Sq.ft.	Sq.ft.	Sq.ft.	Sq.ft.	Sq.ft.
1	0.005	0.007	0.008	0.009	0.011	0.012	0.014	0.016	0.018	0.020
2	.022	.024	.026	.029	.031	.034	.037	.040	.043	.046
3	.049	.052	.056	.059	.063	.067	.071	.075	.079	.083
4	.087	.092	.096	.101	.106	.110	.115	.120	.126	.131
5	.136	.142	.147	.153	.159	.165	.171	.177	.183	.190
6	.196	.203	.210	.216	.223	.230	.238	.245	.252	.260
7	.267	.275	.283	.291	.299	.307	.315	.323	.332	.340
8	.349	.358	.367	.376	.385	.394	.403	.413	.422	.432
9	.442	.452	.462	.472	.482	.492	.503	.513	.524	.535
10	.545	.556	.567	.579	.590	.601	.613	.624	.636	.648
11	.660	.672	.684	.696	.709	.721	.734	.747	.759	.772
12	.785	.799	.812	.825	.839	.852	.866	.880	.894	.908
13	.922	.936	.950	.965	.979	.994	1.009	1.024	1.039	1.054
14	1.069	1.084	1.100	1.115	1.131	1.147	1.163	1.179	1.195	1.211
15	1.227	1.244	1.260	1.277	1.294	1.310	1.327	1.344	1.362	1.379
16	1.396	1.414	1.431	1.449	1.467	1.485	1.503	1.521	1.539	1.558
17	1.576	1.595	1.614	1.632	1.651	1.670	1.689	1.709	1.728	1.748
18	1.767	1.787	1.807	1.827	1.847	1.867	1.887	1.907	1.928	1.948
19	1.969	1.990	2.011	2.032	2.053	2.074	2.095	2.117	2.138	2.160
20	2.182	2.204	2.226	2.248	2.270	2.292	2.315	2.337	2.360	2.382
21	2.405	2.428	2.451	2.474	2.498	2.521	2.545	2.568	2.592	2.616
22	2.640	2.664	2.688	2.712	2.737	2.761	2.786	2.810	2.835	2.860
23	2.885	2.910	2.936	2.961	2.986	3.012	3.038	3.064	3.089	3.115
24	3.142	3.168	3.194	3.221	3.247	3.274	3.301	3.328	3.355	3.382
25	3.409	3.436	3.464	3.491	3.519	3.547	3.574	3.602	3.631	3.659

Table 43.--Areas of circles (basal areas) --Continued

Diameter (full inches)	Area by additional fraction of inch of diameter									
	0.0 inch	0.1 inch	0.2 inch	0.3 inch	0.4 inch	0.5 inch	0.6 inch	0.7 inch	0.8 inch	0.9 inch
	Sq.ft.	Sq.ft.	Sq.ft.	Sq.ft.	Sq.ft.	Sq.ft.	Sq.ft.	Sq.ft.	Sq.ft.	Sq.ft.
26	3.69	3.72	3.74	3.77	3.80	3.83	3.86	3.89	3.92	3.95
27	3.98	4.01	4.04	4.06	4.09	4.12	4.15	4.18	4.22	4.25
28	4.28	4.31	4.34	4.37	4.40	4.43	4.46	4.49	4.52	4.56
29	4.59	4.62	4.65	4.68	4.71	4.75	4.78	4.81	4.84	4.88
30	4.91	4.94	4.97	5.01	5.04	5.07	5.11	5.14	5.17	5.21
31	5.24	5.28	5.31	5.34	5.38	5.41	5.45	5.48	5.52	5.55
32	5.59	5.62	5.66	5.69	5.73	5.76	5.80	5.83	5.87	5.90
33	5.94	5.98	6.01	6.05	6.08	6.12	6.16	6.19	6.23	6.27
34	6.31	6.34	6.38	6.42	6.45	6.49	6.53	6.57	6.61	6.64
35	6.68	6.72	6.76	6.80	6.83	6.87	6.91	6.95	6.99	7.03
36	7.07	7.11	7.15	7.19	7.23	7.27	7.31	7.35	7.39	7.43
37	7.47	7.51	7.55	7.59	7.63	7.67	7.71	7.75	7.79	7.83
38	7.88	7.92	7.96	8.00	8.04	8.08	8.13	8.17	8.21	8.25
39	8.30	8.34	8.38	8.42	8.47	8.51	8.55	8.60	8.64	8.68
40	8.73	8.77	8.81	8.86	8.90	8.95	8.99	9.03	9.08	9.12
41	9.17	9.21	9.26	9.30	9.35	9.39	9.44	9.48	9.53	9.58
42	9.62	9.67	9.71	9.76	9.81	9.85	9.90	9.94	9.99	10.04
43	10.08	10.13	10.18	10.23	10.27	10.32	10.37	10.42	10.46	10.51
44	10.56	10.61	10.66	10.70	10.75	10.80	10.85	10.90	10.95	11.00
45	11.04	11.09	11.14	11.19	11.24	11.29	11.34	11.39	11.44	11.49
46	11.54	11.59	11.64	11.69	11.74	11.79	11.84	11.89	11.95	12.00
47	12.05	12.10	12.15	12.20	12.25	12.31	12.36	12.41	12.46	12.51
48	12.57	12.62	12.67	12.72	12.78	12.83	12.88	12.94	12.99	13.04
49	13.10	13.15	13.20	13.26	13.31	13.36	13.42	13.47	13.53	13.58
50	13.64	13.69	13.74	13.80	13.85	13.91	13.96	14.02	14.08	14.13

Huber's Formula

The volume of a truncated paraboloid may be obtained from the length and a single measurement of diameter taken at the middle by means of Huber's formula. This is:

$$V = A_{\frac{1}{2}} \times L$$

in which $A_{\frac{1}{2}}$ is the mid-cross-section area, V the volume and L the length. If the volume is to be in cubic feet, the length should be measured in linear feet, and the mid-cross-section area in square feet. Basal area tables giving the area in square feet directly for any given diameter in inches may be used.

Example: The cubic feet of a stick 4 feet long, having a middle diameter of six inches would be:

$$V = .196 \times 4 = .784 \text{ cu. ft.}$$

(.196 is the area in sq. ft. of a 6" circle)

Miscellaneous Data

1. In determining trees to cut and leave in ponderosa pine stands in the Southwest to be managed for the production of sawtimber products use the adaptation of Keen's system as presented by Walter G. Thomson in the Journal of Forestry of July 1940. Thomson's article is entitled "A Growth Rate Classification of Southwestern Ponderosa Pine" and is found on pages 547 to 553 inclusive. Volume 38, No. 7.

2. For species other than ponderosa pine use Forest Service marking rules as a basis for determination of trees to cut and leave.

3. Additional data of value prepared by the Forest Service supplementing Thomson's article can be found in:

   Quincy Randles' memorandum of March 21, 1931
   No. 52-S-2 and

4. Quincy Randles' memorandum of April 22, 1939, covering ponderosa pine studies on the Sitgreaves National Forest with respect to pathological rotation.